THE PREVENTION OF DAMPNESS IN BUILDINGS

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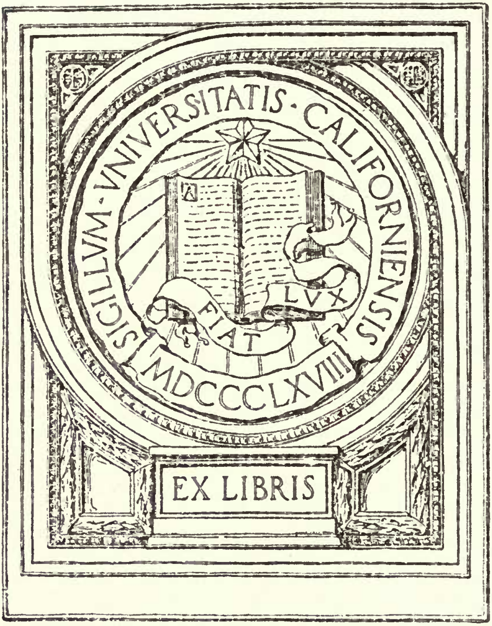
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THE PREVENTION OF DAMPNESS IN BUILDINGS.

THE PREVENTION OF DAMPNESS IN BUILDINGS

WITH REMARKS ON THE CAUSES, NATURE, AND EFFECTS OF SALINE EFFLORESCENCES AND DRY-ROT

FOR

ARCHITECTS, BUILDERS, OVERSEERS, PLASTERERS,
PAINTERS, AND HOUSE-OWNERS

By ADOLF WILHELM KEIM
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Translated from the German of the Second, Revised, Edition

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WITH EIGHT COLOURED PLATES AND ELEVEN ILLUSTRATIONS

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PREFACE
TO THE SECOND EDITION.

AT the desire of the publishers this second edition has undergone complete revision, and has been enlarged in accordance with the most recent improvements. The older portions, so far as they have any value, historical or otherwise, have been intentionally retained unaltered.

During the last twenty years such marked advances have been made in the practical methods connected with this subject, that the problem of the rational drying of new buildings, and of damp walls and dwellings, as well as the prevention of dry-rot, has been completely and appropriately solved.

Attention has been devoted to the theory of the action of the various processes, so that both experts and the general public will each be able to obtain from the book the information and instruction which they require.

1901.

PREFACE
TO THE FIRST EDITION.

THE present treatise is intended to place before the reader only those facts extracted from the very copious literature on the subjects of dampness in walls, corrosion of brickwork, and dry-rot in houses, which have received the attestation of experience. Its object is further to afford to house builders and owners the means of forming a judgment, in each special case, with regard to the source of the mischief, and as to the selection, action, and significance of the remedy to be applied, and the appropriate mode of employing it.

The incompleteness of the existing literature dealing with this subject is chiefly attributable to the fact that the authors have either confined their attention to means of preventing dampness from showing itself, without at the same time attacking the cause of the evil, or else they prescribe only remedies suitable for individual cases. Everyone practically concerned with the subject will, moreover, admit that we have no superfluity of clear and concise treatises on this subject, which both contain appropriate remedies suitable to all circumstances, and also point out the correct methods of applying them.

The author has therefore made it his special endeavour to elucidate, in the narrowest possible compass, the nature and causes of dampness in houses, and of the disorder known as dry-rot, on the basis of science and practical experience, to describe the preventive and remedial methods, and to show the correct mode of employing them in the various cases which occur in practice. He has therefore in the present work supplied unreservedly, and without any personal ends, the results of his long and varied experience, together with a new method employed and confirmed by himself, and it will be a satisfaction to him if hereby he has been able adequately to fill up a vacancy in our technical literature.

PART I.

PREVENTION OF DAMPNESS IN BUILDINGS.

CHAPTER I.

ON THE VARIOUS CAUSES OF DAMPNESS AND DECAY OF THE MASONRY OF BUILDINGS, AND THE STRUCTURAL AND HYGIENIC EVILS OF THE SAME.

DAMPNESS, which so frequently shows itself in dwelling-houses, is by no means produced, as is generally supposed, in all cases by one and the same cause, but may arise from most varied circumstances, several of which may operate simultaneously. The causes of dampness may be briefly summed up as follows :—

1. In the majority of cases dampness in walls is to be traced to ground moisture, which the brickwork absorbs by capillary attraction[1] from a wet soil, and which becomes evident chiefly in the basement apartments of the building. In houses built without cellars, the external walls come into contact with the soil on three surfaces, namely, the base and the outer and inner

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[1] *Vide* Franz Neumann, *Vorlesungen über die Theorie der Capillarität* (Lectures on the Theory of Capillary Attraction) ; *Baugewerkszeitung* (Building Trade Gazette), 1884, 325 ; Wangerin, Leipzig, 1894 ; and "Vorschläge, das Eindringen der Feuchtigkeit in die Mauerwerke zu verhindern" (Proposals for Preventing the Penetration of Moisture into Masonry), Schaffeinsky, *Transactions of the Society for the Promotion of Industries in Prussia*, v. 264.

faces; when there are cellars, this contact occurs on two surfaces only: the base and the exterior face. The partition walls are in contact with the soil at their bases only when there are cellars to the house, but at three faces where no cellars exist. In consequence of capillary attraction the moisture of the soil penetrates any porous substance, such as building stone or wood which is in contact with it, and an unavoidable result is the dampness of porous foundation walls, from which the moisture rises, often to a height of several yards above the surface of the earth, into the upper part of the walls.

This is best seen in buildings standing on boggy ground, where it is often impossible to find in the whole locality a single dry exterior wall, or in places where only porous or hygroscopic materials are employed.

Besides the moisture rising directly from the ground, the external walls of a building are exposed to the action of drifting rain, and to rain-water and snow lying against their bases. Rain-water and snow affect chiefly the lower parts of the external walls (as well as any projections which are not protected or arranged in such a way as to carry off the water), since they drain down the walls, and, unless the house is protected by suitable plastering, come immediately into contact with the foundations. Falling rain is also splashed against the walls, often to a height of several feet, and attacking both mortar and stone, in conjunction with other agents, rapidly destroys them.[1] The partition walls are as a rule completely protected against this action.

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[1] To form a correct idea of the destructive and alterative action which water is capable of exercising on building materials, it is necessary to consider somewhat more closely its physical and chemical properties. Water is a compound of two gases, hydrogen and oxygen (H_2O); not, as was formerly supposed, a simple and undecomposable substance. It is known in three states of aggregation: solid, as ice; liquid, as ordinary water; and gaseous, as steam (or water vapour). On freezing, or passing from the liquid to the solid state, water expands; ice, consequently, has a lower specific gravity (0·94) than liquid water at 32° Fahr. Water is at its greatest density at 39° F.; it expands when

2. A second cause of dampness in walls may be found in the introduction of hygroscopic salts in the building materials employed (stone, sand, lime, well-water, and especially mortar containing gypsum), which absorb water from the atmosphere, and also tend to produce efflorescences.

3. Dampness may also result from too rapid and careless construction; when, for instance, the brickwork is run up very

either warmed or cooled from this temperature. The expansion on freezing is but small (about $\frac{1}{10}$th), nevertheless its effect may be very great, since water when it freezes is capable of bursting the strongest iron vessel which is filled with it. Stone, into the pores of which water has penetrated, is therefore burst and crumbled by the augmentation of the volume of the water on the occurrence of a winter frost.

Owing to its solvent power, water is never found pure in nature since it dissolves the soluble substances with which it comes in contact, as gypsum, magnesium sulphate, common salt, etc.; when it contains carbonic acid it dissolves also various carbonates, which then increase the power of the water to produce chemical changes.

Dr. H. Gredner (*Elements of Geology*, Leipzig, 1878) says, with reference to the geological action of water, that in the all-penetrating water-drop is to be recognised the agent to whose silent but never-ceasing activity the present form of the surface of the earth is due. The varied means by which it performs its mission correspond to the magnitude and difficulty of the duties imposed upon it. If its mechanical power is insufficient for the transport and destruction of the masses of rock which lie in its course, its power of chemically dissolving and disintegrating the stone comes to its assistance; and if both together are too weak for overcoming the obstacle, they ally themselves with frost. The water then assumes its solid form, and during the change of state expands with such irresistible force that it crumbles the stony mass. Before the perpetual chemical and physical activity of microscopic water-drops, huge rock masses disappear, etc. etc. Water which has permeated the rocks of the crust of the earth, carrying with it dissolved carbonic acid, oxygen, and organic substances, brings about the most varied chemical and hydro-chemical reactions, since, apart from its solvent action on readily soluble substances of comparatively rare occurrence (iron vitriol, copper vitriol, alum, saltpetre, etc.), there are four varieties of rock which atmospheric water is capable of dissolving, namely, gypsum, rock salt, limestone, and dolomite. It must, moreover, be recognised that no rock is either absolutely impermeable, undecomposable, or insoluble. That even fine-grained rocks are permeable is shown by the complete decomposition of many basalts and granites, and that liquids find their way into apparently completely homogeneous minerals is evidenced by the artificial colouring of chalcedony and agate. In short, no variety of mineral substance resists absolutely the penetration of water.

rapidly and the plastering is done before the brickwork is dry, since by this means the water, which is partly chemically, partly mechanically, held by the materials, dries out with great difficulty, whilst the action of the carbonic acid of the air on the hydrate of lime (upon which the hardening of the mortar depends), and the consequent escape of the water of hydration, is very much prolonged. Such buildings require very thorough aëration and drying after the mortar has hardened before they are inhabited; otherwise there is a danger of their remaining damp, and of rotting of the woodwork and corrosion of the walls being the result.

4. Damp walls are often the result of the condensation of water vapour in kitchens, dwelling-rooms, churches, etc., which takes place chiefly on the thinner and colder parts of the walls.

5. Finally, dampness of walls and ceilings is very often due to local causes, such as leaky roofs, damaged gutters, overflows, insufficient airing of the rooms, etc. In such a case, if the mischief has not gone too far, it will rapidly right itself when the cause is removed.

The extremely injurious effect of damp dwellings on the health of the inhabitants, and the serious results with regard to the durability of the building itself, are so well known that it would scarcely be believed how much the matter is neglected by most people; far too little care being taken (especially in country places) either for the construction of sound dwelling-houses or for the care and preservation of the edifices themselves. Numerous cases of illness may be referred simply and solely to the use of damp, unsound dwelling-rooms, the air of which is saturated with foul vapours, and which are insufficiently or never aired, and medical men cannot lay too much stress on the insalubrious results arising therefrom. We are acquainted with many cases where persons have fallen ill in damp dwellings, where for months and years the illness has resisted all the skill and energy of physicians, but where a change to a dry dwelling, exposed to light and fresh air, has sufficed in a short time to restore health.

Just as a healthy mind can only be maintained in a healthy body, so, amongst other things, a condition of a healthy body is a healthy dwelling, which must be dry and warm, and freely exposed to light and air. Such a dwelling promotes the well-being of the whole person, the healthiness of body, soul, and spirit.

J. Schmölke[1] remarks, however, only too justly, "that the importance of having dwellings free from mouldiness and fungoid growths has hitherto been far too little appreciated from a hygienic point of view. Very frequently this consideration is lost sight of altogether, and many a dwelling in which children are brought up is so conditioned that any owner would hesitate to use it as a stable. In the latter there would at least be more ventilation. And this, notwithstanding that the conditions of the dwelling have the greatest possible influence on the health and the bodily and intellectual development of a people, a social class, a family, and an individual."

We shall always find that damp houses are cold houses, because the air in the rooms is always cold and damp. Such houses are insalubrious, because they rob our bodies of much of their necessary heat; hence result paleness, coldness of the extremities, catarrh, rheumatism, consumption, etc. The colder our environment the more it abstracts the heat from our bodies.

Prof. Max von Pettenkofer, in his popular discourse on the relation of air to clothing and soil,[2] says—

"The entire range of vital action is connected with chemical processes which go on in our bodies, which processes are maintained by the solid and liquid food which we take, and by the oxygen which is absorbed from the air. The regular course of these processes is, amongst other conditions, associated with a definite temperature, both above and below which the processes are indeed not arrested, but take a different course, so that they no longer fulfil the requirements of normal life, but result in disease or death."

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[1] J. Schmölke, *Die Verbesserung unserer Wohnungen nach den Grundsätzen der Gesundheitspflege* (The Improvement of our Dwellings on Hygienic Principles). Wiesbaden: J. T. Bergmann.

[2] Brunswick: Vieweg & Son.

Damp dwellings further contribute to the formation and decomposition of organic products injurious to health, inasmuch as they supply the most favourable conditions for the development of germs deposited from the air. Glue, paste, wall-paper, woodwork, and furniture are attacked, begin to rot, their products of decomposition contaminate the air, and finally there often shows itself the dangerous and justly dreaded dry-rot.

According to Dr. Hüllmann of Halle-am-Saale, the insalubrity of new houses is solely due to the wetness of the walls. As a consequence of this wetness the walls are impervious to air, ventilation is hindered, formation of mouldiness is favoured, disease germs find a resting-place suitable to their development, the walls are maintained in a cold state, and lower the temperature of the air in the rooms.

Even the masonry is gradually destroyed by a persistent state of dampness; stone and mortar are both attacked, and undergo changes which seriously affect the duration of the building. Saline efflorescences show themselves, the cement falls off and exposes the brickwork to still more considerable absorption of water, which, on the occurrence of frost, splits and crumbles both stones and joints, until by the alternating action of frost and heat, wetness and dryness, they are completely disintegrated and fall to powder. Then, in the summer time, plants and insects help on the work of destruction by penetrating the joints of the masonry and the cement, and, in conjunction with the former agents, effect the complete ruin of the building.

It is especially the rain which washes out the mortar from the joints of the brickwork in immediate proximity to the soil, whence it frequently results that in houses whose foundations lie below the level of the street pavement the water penetrates into the apartments, or, if the inner surfaces of the walls are covered with impervious cement, finds a channel towards the exterior between the cement and the brickwork. Moreover, as was remarked at the commencement, the efflorescences which are produced on walls as a result of persistent dampness may in their turn become a cause of dampness. These efflorescences are just as injurious to brickwork as dry-rot is to woodwork.

The so-called "saltpetering,"[1] which chiefly shows itself in damp places where nitrogenous organic substances of animal or vegetable origin are undergoing decomposition in presence of lime, or other strong bases, arises from the formation of nitrates, especially of nitrate of lime. But even in localities where these conditions are completely absent, incrustations of salts are found which absorb moisture and are readily soluble in water, and which have been introduced in the materials. These efflorescences are always met with in places where there is a lack of fresh air. Both these kinds of saline incrustation are included in the general term "Mauerfrass," but only the former can correctly be called "saltpetering," which, however, is the more injurious in its action on brickwork.

It shows itself on the surface of walls at first by the production of moist spots, which then become covered with a thin white film, and eventually exhibit distinct crystalline formations. The paint then falls off from the wall, and subsequently the whole coat of cement; the walls no longer become dry, and very soon the whole of the brickwork becomes soft, so that it can be broken away and crushed by the fingers.

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[1] The word "Mauerfrass," employed in the German, means literally "corrosion, or eating away of walls," but it is used in this work to designate the saline efflorescence—generally impure calcium nitrate or lime saltpetre—which appears on the surface of masonry which has absorbed water containing nitrogenous substances in solution. The two phenomena, although specifically distinct, are often concurrent; whence in popular phraseology a single word is used to express both.—Note by Translator.

The mortar removed from brickwork destroyed in this manner has a cool, saline taste, and forms white, woolly efflorescences. After a time these efflorescences show themselves, not only on the surface of the plaster but also below the plaster, and between it and the joints of the brickwork. The saline incrustations may contain nitrate of lime, gypsum (sulphate of lime), sulphate of magnesia, sulphate and carbonate of soda, chloride of calcium, etc. They, moreover, sometimes contain common salt (sodium chloride) and small quantities of potassium chloride. Bleichrodt[1] says quite correctly that only these deliquescent salts are the real agents in the corrosion of walls (Mauerfrass), and that they effect the gradual decomposition of the cement and the removal of the lime.[2]

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[1] W. G. Bleichrodt, *Theoretisch-praktische Abhandlungen über die Ursachen der Feuchtigkeit, etc.* (Theoretical and Practical Treatise on the Causes of Dampness, etc.). Weimar: Voigt.

[2] *Vide* Kuhlman, "Ueber die Ausblühung (Auswitterung) der Mauern" (On the Efflorescence of Walls), *Annalen der Chemie und Pharmacie*, von Liebig und Wöhler, xxxviii. 42; and Vogel, "Ueber das Ausblühen der Mauern, oder Verwittern der Wände an Gebäuden," etc. (On the Efflorescence of Walls, or the Weathering of the Walls of Buildings, etc.), *Kunst-und Industrieblatt*, 1842, 261, which works have obtained more recent confirmation, as, for example, by Prof. Feichtinger, who analysed the efflorescence from a new brick building with the following result:—

Soda	41·12
Potash	0·84
Magnesia	Traces
Lime	1·02
Chlorine	Traces
Carbonic acid	Traces
Sulphuric acid	51·93
Insoluble	4·88
	99·79

Wagner, *Jahresbericht der Chemischen Technologie.*

The aforesaid salts, which are mostly very hygroscopic, absorb water from the atmosphere when this is in a damp state, then saturate the bricks and cement with their solutions, and when dry, warm weather ensues, disintegrate both by the expansive power of crystallisation. They sometimes exhibit a crystalline appearance, at other times a powdery one, according to the gain or loss of water of crystallisation. If the air is moist enough, during a rainy season, for example, the efflorescences disappear,because they dissolve in the rain-water and their solutions are absorbed by the brickwork, to recrystallise when the wall becomes dry again. These salts, with the exception of the nitrates, are derived chiefly from the building materials, into which they are generally introduced by the coal employed for burning the bricks and lime. To their action must be added the expansive power of the ice formed during winter in the pores of the wall, and thus the process of disintegration, once it has reached a certain stage, proceeds uninterruptedly towards total destruction.

Besides the hygienic and material mischief resulting from damp and disintegrated walls, Vaudoyer[1] draws attention to the injurious effect of the weathering of mortar and stone upon the architectural characteristics of the building.

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[1] *Essay on the Means of Preventing Dampness in Houses.* By M. L. Vaudoyer. Quedlinburg: G. Basse.

CHAPTER II.

PRECAUTIONARY MEASURES DURING BUILDING AGAINST DAMPNESS AND EFFLORESCENCE.

JUST as it is easier to prevent the occurrence of epidemic diseases by suitable precautions than it is to stamp them out when once they have become established, so is it both easier and less costly to take steps for the prevention of dampness and efflorescence when planning and constructing a building than it is to get rid of them when once they have obtained a hold in the completed structure. The cost of prevention is insignificant in proportion to the cost of remedying the defect later on; moreover, as we shall see, there are at command a far greater number of well-tried and simple preventive means than there are of approved methods of abolishing dampness from finished buildings.

Vaudoyer, in the work already cited, lays down the following general principles with regard to dampness as affecting buildings, as also with reference to the means of counteracting it:—

"1. Dampness is one of the greatest scourges to be feared in our houses; it must be prevented and checked before it reaches those parts where it may become injurious.

"2. The only efficient obstacles which can be opposed to it are sheet-lead, coatings of fatty, pitchy, or resinous substances, and certain mortars which are recommended for this purpose. We are far from disparaging the various impervious coatings which we daily see employed with more or less success, but it must be recognised that we abstain from recommending any of these, leaving it to each person to select the one which, according to his own experience, may best be used in a given case.

"3. Isolation and the circulation of air are the best means of preventing the intrusion of dampness into any body.

"4. If a building cannot be protected by ordinary methods, those materials must be employed which are least hygroscopic, and must be kept as distant as possible from the soil.

"5. It will always be the most advantageous course to provide during the building of a house for the prevention of dampness, for it is far more difficult to combat and expel it when it has obtained a hold in a completed structure.

"6. Before commencing a building it is necessary to ascertain the modes in which moisture may obtain admission to it, next to decide on the nature of the preventive methods, and then the point at which these shall be applied, taking into consideration the special circumstances of the buildings."

In what follows I fully describe some of the more approved preventive methods which come within the range of these considerations, and supply particulars relative to every material, whether brick or sandstone, whether cellars are present or not, etc.

The first precaution in constructing a building is to select the locality and soil upon which the structure is to stand, then the aspect[1] for the front of the house, and lastly, to choose the best materials where a variety is accessible.

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[1] "The beneficial action of sunlight cannot be too much insisted on; experience proves it. Walls with a south aspect suffer far less from atmospheric influences than those of northerly aspect, and this chiefly in consequence of the action of the sun. In Italy it rains less frequently than in Germany, although the total amount of rain is equally large; nevertheless buildings suffer less from damp there because the heat of the sun gets rid of it. It is chiefly when it is persistent that damp is so prejudicial. In Paris it is quite sufficient to compare the north and south walls of the houses to convince oneself of the marked difference between them. In France it is the walls with a westerly aspect which are the most unfavourably situated, for they are exposed to the westerly rains, and are not reached by the rays of the sun until that body has so far approached the horizon as to lose much of its

As far as possible, a boggy locality, surrounded by pools or standing water, or a low-lying one, should be avoided, and an elevated, open, and airy position should be chosen.

Demich[1] advises that the ground on which the house is to stand should always be examined as follows: "In order to ascertain the nature of the ground, let holes first be dug to a depth of a yard, and into these water be poured. After this has become quiescent, observe whether bubbles rise through the water. Should this occur, it is evidence that the spot was formerly a bog, which has become filled up. The bubbles which are observed are the so-called 'marsh gas,' which, coming in contact with the atmosphere, can be set on fire, and is believed to be the cause of the *ignis fatuus* of boggy places. Secondly, let warm water be poured over the excavated earth; if, after some hours, an ammoniacal odour is noticed, this is

heating power. The easterly frontages, on the contrary, are the most favourably situated, since they are completely protected from rain, and are exposed to the sun for the greater part of the day. The same is the case in Munich.

"Although we admit that a southern aspect is the most favourable, we must not disregard the changes which southerly walls undergo in consequence of inferiority of the building materials or defects in their use. As an example, we may cite the case of the Louvre, many portions of which are completely disintegrated whilst neighbouring parts are well preserved. This building is indeed in a very inferior state of preservation, because the soil on which the foundations rest has never been concreted.

"The frontages of buildings with a northerly aspect are exposed to a source of injury for which hitherto no remedy has been found. There is a variety of spider which inhabits the crevices between the stones and spins a web which gradually covers the surface of the wall. This web catches the dust, and, besides disfiguring the building, it assists the growth of incrustations by absorbing the moisture of the atmosphere. It would be advisable for buildings thus affected to be swept down every eight or ten years, and even better that they should be protected by paint from the ravages of these creatures.

"The remarks which we have made on the southerly aspect of buildings are not applicable to wooden structures, for which, on the contrary, this aspect is very disadvantageous, since wood which is alternately exposed to wet and heat readily rots" (Vaudoyer).

[1] C. G. Demich, *Neueste Entdeckungen, die Feuchtigkeit und Dünste durch physische Apparate, etc., zu verscheuchen* (The Most Recent Inventions for getting rid of Damp). Bautzen: F. A. Reichel.

evidence that there formerly existed a stable or manure heap on the spot."

If such a place as this must nevertheless be made use of, extra care must be taken to exclude the ground water and the gases escaping from the soil, and render them harmless. If the soil is wet and boggy it must be dried by running drains through it to carry off the water. The house must be surrounded by a deep drain, with an outlet for the water; the drain itself to be covered in.

If possible the front of the building should face the south or east in order to benefit as much as possible by the sun's rays.

The material for the footings should be the best stone and good hydraulic cement. The best concrete is undoubtedly that made with good Portland cement and sand, the preparation of which is to be found in any treatise on building materials. Such concrete should be employed for the foundations and plinths to a height of at least eighteen inches from the earth.

For the superstructure, well-burnt (but not overfired) bricks should be used, these being far superior to most natural stones, soft argillaceous sandstones, which absorb moisture from the air and alternately exude and reabsorb it. Good bricks absorb far less moisture, retain it for a shorter time, and are bad conductors of heat; they therefore constitute the driest and warmest outer walls. The mortar for the superstructure should be prepared from lime which, after being well slaked, has been left for some time in pits for the removal of the soluble salts which it contains, and to reduce it to a more uniform condition than would be the case if used when freshly slaked. For the sand, any stone, whether limestone, quartz, or felspar, reduced to a granular powder, will serve, provided it is free from clay or loam. But as this sand is often very impure it ought to be well washed. Preference should be given to sharp river sand, because it exposes the greatest amount of surface to contact with the lime. Good sand must therefore be free from all earthy matter, and, when stirred up with clean water, should cause but little turbidity. The sand should not ball when squeezed in the hand, should grate when pressed, and have an angular appearance. It should not soil a white cloth with which it is brought in contact. It should be freed from saline and earthy impurities by washing. As regards its suitability for making mortar, and the size of its granules, sand is divisible into three classes, namely, fine sand, generally used in fine stuff for the setting coat; medium, for brickwork; and coarse, for stone walls. Rain or brook water is to be preferred to well-water, which often contains much saline matter.

With regard to mortar, Bühler remarks that this highly important building material has in recent times become better understood in consequence of the advances in chemistry and the building arts; its preparation and employment have been based on correct principles, and, as a result of this improvement, its use in a truly rational manner in the higher branches of the art of building has much increased: that, on the contrary, in low-class buildings, the injurious practice has gained ground of using, as mortar, road refuse consisting of unburnt calcareous matter mixed with humus and other vegetable substances, instead of well-burnt, well-slaked lime. There can be no doubt that this practice, which owes its remarkable extension to the use of calcareous stone for road-making, greatly facilitates the production of fungoid growths in walls.

When commencing a building great attention should be given to securing good foundations, especially in places where the subsoil water at its lowest level is nevertheless above the base of the foundations (Fig. 1, *b*). A good plan is to puddle the trench excavated for the four exterior walls with a layer of plastic clay about 16 inches wide and 8 to 12 inches thick, ramming it firmly down. Upon this is laid a bed of concrete, prepared from 2 parts of Portland cement, 3 parts of sand, and 5 parts of natural stone, broken to the size of nuts and

PREVENTION OF DAMPNESS IN BUILDINGS.

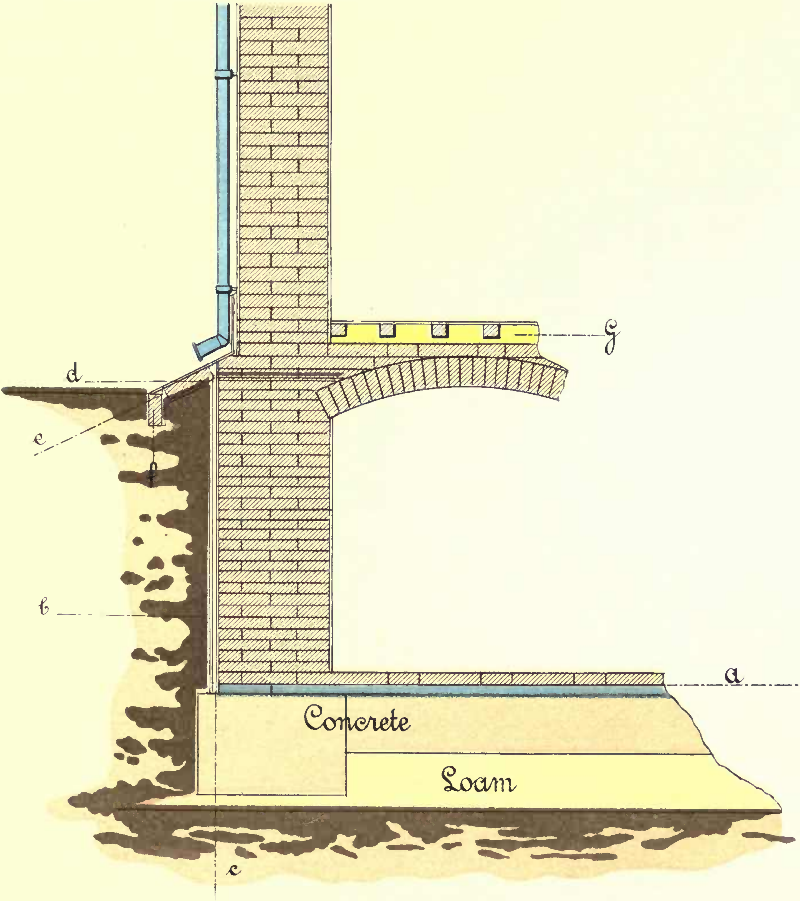

Fig. 1.

washed. These are mixed dry, thrown into the trench, then wetted with a watering-can, and firmly rammed down. At the places where the weight of the outer walls is to bear, it is especially advisable to thicken and widen the concrete layer (Fig. 1). And to prevent entirely the possibility of moisture, saline substances, vapours, and gases rising from the soil, the whole surface should be covered with a layer of asphalt (Fig. 1, line *a*), and upon this the cellar paving may be laid.

The brick footings may now be put in, taking all possible precautions that they do not serve as conductors of soil moisture. The following method of treatment is in part due to Bühler.

The best mortar should be used, and care must be taken in laying the bricks that the mortar comes into intimate contact with all their surfaces, without, however, making the joints thicker than necessary. The use of argillaceous stone should particularly be avoided, as such stone would absorb much water. It is, moreover, indispensable that all parts of the wall should be carried up to an equal height at the same time, in order to avoid irregular pressure on the concrete layer, which might crack it. The joints, both at the inner and outer surfaces, should be pointed with fine cement, and the outer surface, from the level of the concrete to a foot above the ground line, should be coated with a layer of glazed tiles set in mortar : no moisture can then obtain access from this quarter (Fig. 1, line *c*). The isolation of the underground work can also be attained by building, as in Fig. 1 *a*, a dwarf wall a little way from the main wall, forming a dry area, and carrying the retaining wall up to the level of the street pavement. When in this manner the main walls have been built up to a little above the ground line, the whole upper surface of the work is to be covered with a thin coating of some substance impervious to water (Fig. 1, line *d*). This will prevent any trace of moisture from penetrating into the superstructure. The material employed for this waterproof layer may be poured over the work in a liquid state, or the end may be gained by using a thin sheet of lead, or the flexible asphalt slabs supplied by A. W. Andernach of Beuel-on-Rhine. In Chapter III. a variety of recipes for this purpose will be given. Of all methods, however, the most efficient is to construct the whole of the foundations, up to about twenty inches above the ground line, of good concrete. For the protection of the lower parts of the walls from splashed rain, they should be coated to a height of a few feet with cement mortar. For carrying off rain-water good gutters and drains must be provided.

The cellars must be so constructed that abundance of fresh air can obtain access to them, and that light may not be altogether excluded. When there are to be no cellars, a stratum of coarse dry gravel should be laid on the concrete bed, and above this a layer of fine dry sand, or, still better, one of powdered infusorial earth (Kieselguhr) (Fig. 1, line *g*), the cost of which is not excessive.

A treatise by E. Nöthling, *The Protection of our Dwellings from Damp*, Weimar, 1885, is strongly recommended to all who are concerned with this subject.

The privies, or at least the cesspools, should as far as possible be located externally to the building. Fig. 2 shows one of these as recommended by Bleichrodt, which, however, is architecturally only fitted for a cottage. The system of movable close stools (*fasses mobiles*), which (in Germany) has been adopted in many towns, is very advantageous.

We proceed to quote the instructions of various authorities on methods of combating dampness.

Leo v. Klenze, President of the Supreme Building Council in Munich, employs the following method for preventing ground moisture from rising in the walls of new buildings. As soon as the foundation walls have reached a level a few inches below the ground level, the entire area of the walls is to be covered with tar-mortar to a thickness of about half an inch. This

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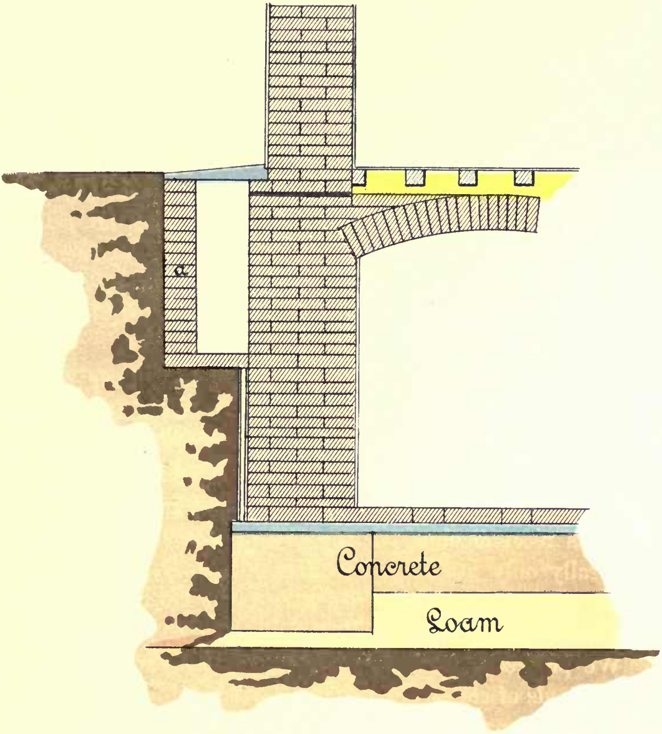

Fig. 1a.

tar-mortar is prepared by mixing hot tar or pitch with fine quartzose sand to the consistence of ordinary mortar. When the work has been thus tarred, sheets of lead foil are laid on the surface, taking care that where the plates meet they should overlap at least an inch, and that they stand out 1–2 inches from the surface of the wall so that their ends can be bent downwards. The sheet-lead is first painted on both sides with caoutchouc varnish to protect the lead from oxidation. Upon these sheets of lead a course of tiles is laid in the same tar-mortar, and above this the brickwork is carried up with ordinary mortar.

Tölken, for the same purpose, makes the following proposal: The foundation walls are built up to about 20 inches above the ground level, and are then covered with a layer of asphalt, which need not be more than $\frac{1}{10}$th of an inch thick, and is perfectly impervious to moisture.

Fleming recommends that at 3 inches above the ground level the bricks should be covered with $\frac{1}{4}$ inch of mortar made with a fine uniform sand, and upon this a layer of glass plates touching one another and standing out $\frac{1}{2}$ inch from the face of the wall. Where the plates butt against one another they should be daubed with warm coal tar for a width of 6 inches, and glass plates of the same width be laid over the joints. The whole is then to be covered with a bed of mortar, and the further erection of the wall be continued in the usual manner.

Vaudoyer recommends, instead of glass plates or sheets of lead, the use of a double layer of glazed tiles,[1] covered with some impervious material.

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[1] The employment of glazing on burnt brick comes down to us from the highest antiquity; the walls of Babylon and Persepolis were faced with bricks glazed with various colours, and similar examples are found later in monumental buildings of various ages. We have no information as to the causes which led to the abandonment of glazed bricks; at all events, the advantages of such bricks have been abundantly recognised. For centuries it has been the custom in the East to clothe the interior walls of dwellings with glazed tiles, which assist in keeping the houses cool, and are at the same time a security

Schmölke employs well-tarred roofing felt as a damp course, laid either in hydraulic cement or a bed of asphalt, and covered with a layer of the same. According to this authority, instead of asphalt coal tar may be used, which has been mixed, whilst hot, with powdered lime to the consistence of ordinary mortar. According to Ernest Nöthling, the firm of Buscher & Hoffmann in Eberswalde supply asphalt plates for the same purpose. Other writers recommend the introduction of two or three courses of bricks saturated with asphalt, followed by a layer of melted asphalt. Another plan is to form blocks with sand and bitumen, and lay these in the wall with asphalt. A mixture of 5 parts of asphalt, 1 part of coal tar, and 2 parts of powdered quicklime, laid on hot $\frac{1}{2}$ to $\frac{3}{4}$ inch thick, answers the purpose well.

Dr. J. W. Fischer has suggested the following waterproof mortar for covering lead plates when these are employed. It is prepared by mixing equal parts of coarsely crushed glass, coal, and well-slaked lime. With this mortar, which assumes on setting a stony hardness, the outer surface of the foundation walls is cemented. Fischer points out, however, that without the sheet-lead this mortar does not prevent the rise of moisture.

The following Russian formula has been employed for many

against damp. Spain borrowed this practice from the East. In the Netherlands the use of such tiles for covering the walls of the ground-floor apartments is very general, the object being doubtless protection against damp, which in that country is particularly to be feared. From the fifteenth, and still more from the sixteenth century, the use of glazed tiles in France for the plainest as well as the most elegant apartments has been adopted : examples were to be seen a few years ago in the Chateaux d'Anet and Ecouen. It is evident that this employment of tiles in the lower rooms hinders the rise of damp from the soil. Glazed tiles have also been used as roofing, and even for the fronts of houses, of which there are some specimens in Beauvais. The Chateau de Madrid in the Bois de Boulogne was renowned for the beauty of the faïence with which its exterior was ornamented, and which was the work of the celebrated Cæsar della Robbia. We could say much on the subject of glazed bricks, but confine ourselves to directing attention to a manufacture which formerly was held in high esteem, but now seems to have fallen into undeserved oblivion.

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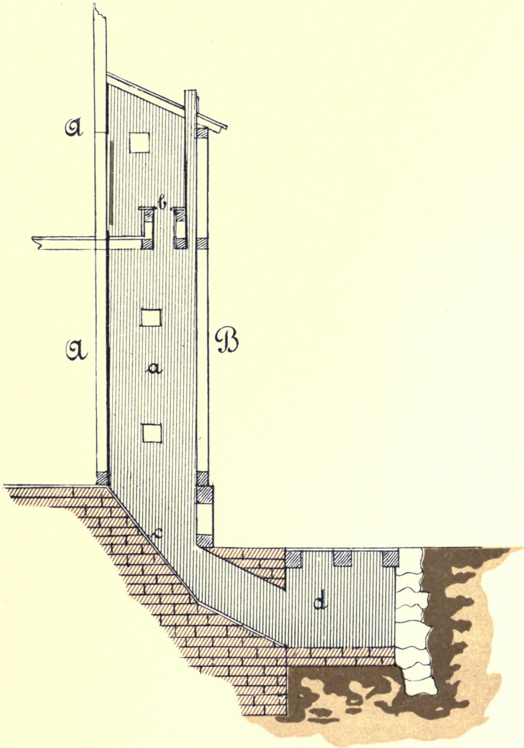

Fig. 2.

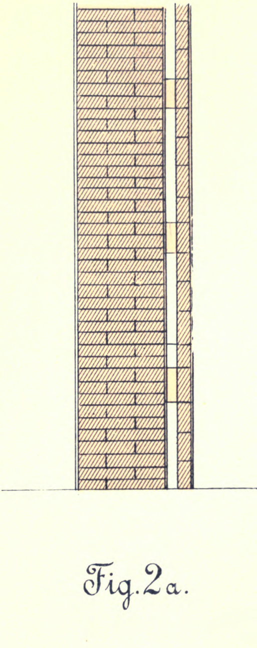

Fig. 2a.

years with the best results by the Erfurt Fortifications Commission. The proportions are given in the old weights and measures.

Forty Berlin quarts of water are heated to boiling in a pan, and 4 lb. of white vitriol (zinc sulphate) added. Then 2½ Berlin Metzen[1] of rye-flour are stirred up with 12 quarts of water, and this pulp is poured into the boiling water whilst stirring continuously. Then 3 lb. 2 oz. (3 Pfund, 4 Loth) of rosin are melted in a glazed earthenware pot over a moderate fire, and poured slowly, with constant stirring (otherwise an explosion might occur), into 20 lb. of train oil, and this mixture is added to the former one and well stirred. There is then added 2 oz. (4 Loth) of ochre and 3 lb. of white lead, and this produces a permanent waterproof material, which is used hot for coating the stones and faces of the foundation walls. The coating must be repeated three or four times with intervals of twenty-four hours for drying.

Portland cement mortar, consisting of 1 part of Portland cement and 2 parts of clean sand (calcareous or quartzose), employed to form a layer 6 to 8 inches thick, forms an efficient damp course.

Weissang's Cement, obtainable from Emil Lichtenauer, of Grötzingen, Baden, also answers the purpose well, although it is not so economical as asphalt. For information respecting this cement see *Correspondenzblatt zum deutschen Maler-Journal*, 1886, p. 163.

The so-called iron-cement or iron-mortar (Dufour-Mantel's Patent) may be used instead of ordinary mortar in all building construction, and serves as a protection against damp. This cement consists of a mixture of artificial hydraulic lime and iron-slag, mixed with coal ash in the proportion of 1 : 4. For other preparations see Chapter III.

As is now sufficiently evident, the success of these methods depends upon the introduction of a waterproof layer into the wall, which, however, in no way dispenses with the use of good bricks and Portland cement. Fig. 1 shows a building in which all the necessary precautions against damp have been observed.

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[1] The Metze is stated to be equal to twelve pecks.—Translator.

The thorough warming of new houses, before they are painted and occupied, is strongly to be recommended. Equally necessary is it that provision should be made for regular and appropriate ventilation of dwelling-houses, stables, wash-houses, etc.

From the year 1877 to 1900 no less than seventy-seven patents have been granted in Germany for ventilating stoves. The best of these can be selected by builders. Dr. Hüllmann recommends the Stegenkolb ventilator.

The introduction of a damp course into the walls of a building is undoubtedly the best means that can be employed during the erection to guard against damp, especially in basements. Preuss, of Breslau, makes the following remarks on the subject: "In building stables and dwelling-houses, inattention to hygienic considerations is but too frequent; notwithstanding that dry walls can be ensured with scarcely any increase of cost. Especial attention should be directed to the advantages of hollow walls. It is frequently considered to be sufficient if precautions are taken against moisture rising from the ground, whilst overlooking the fact that walls may also become damp from exposure to weather outside or to water vapour inside. By leaving in the interior of the wall a cavity two inches across, and communicating by ventilating holes with the outer air, any moisture which penetrates the bricks is rapidly evaporated. If the cavity is completely closed in, the wall will generally remain damp." For further information on hollow walls, see Nöthling (*loc. cit.* p. 15 *et seq.*).

The coating of the inner and outer surfaces of the upper walls of a building with cement should, as far as possible, be delayed until the masonry has become thoroughly dry.

CHAPTER III.

METHODS OF REMEDYING DAMPNESS AND EFFLORESCENCES IN THE WALLS OF OLD BUILDINGS.

MOST of the methods which have been proposed for curing damp walls have been based on the use of waterproof plastering or paint, or depend on the principle of employing hollow walls, with or without ventilating apertures. The former device may in certain cases fulfil the desired end, although as a rule it merely hides the mischief for a time and actually aggravates it. The plan of using hollow walls with ventilating channels, whilst more correct in principle, is both costly and difficult of application to old houses.

Vaudoyer has the following remarks on these two methods: Imagine the wall of a basement to be affected by moisture, and to exhibit efflorescences on its external surfaces; it would be of no use to try to shut the damp into the wall, we must rather afford it an opportunity of being dried by the air, whilst endeavouring to remove the cause. With this object air-channels should be inserted in the walls above the ground level, cellars may be excavated where none already exist, the inner and outer plastering of the walls may be removed, and any precautions similar to those which are employed in new construction may be adopted. In cases, however, in which these precautions are no longer possible, or when, in spite of them, the effects of dampness still continue to exhibit themselves, recourse must be had to other means, such as the following:

To prevent the moisture which is present in the wall of a building, and shows itself on the interior surface, from influencing the air of the apartments, the best plan is to face the wall with hard tiles, set on edge at a distance of about an inch from the face of the wall (Fig. 2 *a*) so as to permit a circulation of air between the wall and the inner casing. It is beneficial to give the inner surface of tiles a coat of asphalt, especially those which are tied to the wall, whilst the outer surface may be coated with plaster (?), which, when perfectly dry, can be painted or papered, or, since wall-paper does not adhere well to plaster of Paris, it may be pasted upon coarse linen.

This system would afford all needful security, and no further harm would arise from the moisture even if it still remained in the wall which was originally affected by it; but even in the wall itself it would be markedly diminished by the ventilation which would be established between the wall and the inner casing. A less expensive expedient would be to erect wooden battens against the wall, with diagonal ties, to nail laths upon these, and then plaster the laths. This would give a thin partition, isolated from the wall. The wooden battens, being in contact with the damp wall, would have no great permanence; they should at least be well tarred, and have sheet-lead interposed between them and the wall: a free circulation of air is, moreover, absolutely necessary. Wooden wainscoting amounts in fact to an isolated partition, and it is certain that the partial, or, if necessary, the complete lining of the walls of a room with wood is a great protection against damp; nevertheless, the ill effects of moisture on the building itself will still have to be feared if a free circulation of air is not provided for behind the wainscot, the back surface of which, moreover, should be well tarred.

Although the system which has just been described is to be preferred to any other, it nevertheless has the disadvantage of reducing the size of the apartment considerably; we have therefore to consider whether other devices may not in some cases be adopted.

In cases where the wall in question is an interior wall separating two apartments, both of which require to be screened from damp, there is no alternative but to adopt the system of isolated partitions; for if any coating impervious to moisture were applied immediately to the wall, the result would simply be to enclose the damp in the substance of the wall, and would promote a destructive action which would be all the more detrimental because it would escape observation. But where the damp shows itself in only one of the rooms, it would seem that to suppress it on that side of the wall would drive it to the opposite one, where, however, it would not be so harmful as in the former case, because at that side the air might be relied on to evaporate it to a large extent. In such a case it is better to avoid the use of an isolated partition, and to apply directly to one side of the wall the waterproof coating which is regarded as the best protective. It must, however, be admitted that few of these will long maintain their coherence with a wall which is perpetually damp. Framed partitions take such a coating more readily than walls built of stone. The material selected for application should, if possible, be one that will penetrate into the substance of the wall. Such an application may also be employed for the inner surface of an exterior wall, if this has a favourable aspect. For if one of the surfaces is exposed to the influence of the air, the damp will be able to escape from the whole thickness of the wall.

Although this plan presents indisputable advantages in some cases, there are others in which the wall may be coated with glazed tiles, affixed with good mortar; or, in rooms where a tiled wall is not appropriate, the rough side may be left exposed, and can then be covered with paint and any desired style of ornamentation. In some instances, tiles saturated with asphalt may be used; in others the whole surface may be covered with thin sheets of lead. The chief difficulty in using metallic plates is to find a suitable material for attaching them to the wall. This is required not only to harden readily, but also to adhere firmly to both the surfaces to which it is applied.

It would be superfluous to remark that a damp wall to which cement, or any other waterproof material, is to be applied, should first be stripped of its former coating, and allowed to dry for some time before the new coat is laid on. And it must further be remarked that rendering with mortar consisting of hydraulic lime and sand gives a surface which is quite unsuited to receive a coat of oil paint, since the latter would not adhere well, but would speedily peel off.

C. G. Demich has proposed some extremely complicated ventilation attachments, which are so costly that scarcely anyone would introduce them into old buildings, on which account I pass them over. But he also gives the following method for protecting against damp :—

An excellent method (he says) of preventing the escape of water vapour from damp walls is to cover them with small glazed clay tablets. These tablets, which can be made by any potter, are about $\frac{7}{8}$ inch square and $\frac{3}{8}$ inch thick (21 mm.[1] long and the same breadth, by 9 mm. thick), and are glazed on one side. They are attached to the wall, with the glazed side outwards, by good mortar or plaster and small clamps. A wall covered with such tablets has not an unpleasant appearance, but, when lighted up at night, the glitter is injurious to the eyes. To avoid this the tablets may be fixed with the glazed side towards the wall, the rough side coated with a thin layer of fine cement, floated, and papered. When the damp is not excessive, the wall may be covered in the same way with old window glass, then floated with cement, and papered.

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[1] Apparently a misprint in the original; 21 *centimetres* (8 inches) is probably intended.—Translator.

In the year 1842 Thenard and D'Arcet employed the following process for drying two low-lying, damp apartments, which belonged to the Faculty of Sciences of the Sorbonne, and the foundations of which were at a depth of several yards below those of the adjacent houses on the east and south. These walls had a thick incrustation of saltpetre. Some years previously it had been thought necessary to coat the walls with plaster, in the hope that the efflorescence would be transferred to the outer surface; but it speedily penetrated the plaster coating and reappeared on the inner surface of the wall, which it kept in such a damp condition that the plaster lost its hardness, and the rooms became uninhabitable even in summer. An experiment was made with these two rooms in the following manner: Linseed oil was boiled with one-tenth of its weight of litharge, and then mixed with twice its weight of rosin, which was dissolved in the oil by heating in an iron kettle over a slow fire. The mixture frothed at first, but soon assumed a quiet state of fluidity. When this stage was reached it was allowed to cool, but was remelted as required for use.

The walls being excessively damp, required to be dried. This was effected by the use of a gilder's furnace, 50 cms. (20 inches) wide and 40 cms. ($15\frac{3}{4}$ inches) high, so that a surface of 1975 square cms. (about 2 square feet) was dried at one time. This furnace was suspended by two hooks from an iron rod $1\frac{1}{2}$ metre (5 feet) long, the ends of which rested in notches in the front edges of two upright boards, which were nearly as high as the room itself (3 metres, or 10 feet), and were joined by cross bars so as to make a readily movable frame. The frame was placed at a convenient distance from the wall, and the furnace was prevented from swinging closer to the wall by two short rods screwed to its ends. It was also furnished with handles, by which it could be held when it was desired to move it along the iron bar. The wall space confronted by the frame might be regarded as divided into eight horizontal sections, each the height of the furnace and three times its length. Operations were commenced with the uppermost section. As soon as a space of the wall equal in area to the front of the furnace was thoroughly dried, the furnace was moved sideways along the iron rod, and whilst a fresh space of the wall was being heated, the varnish was applied to the first part. If the varnish did not readily soak in, the furnace was brought back again to that part of the wall. This caused the emergence of air bubbles from the wall and the rapid absorption of the varnish. This procedure was repeated until the plaster would absorb no more of the varnish. Five coats soaked in, the sixth only partially, leaving a sort of thin glaze on the surface, which ultimately acquired great hardness. The whole surface treated amounted to 94 square metres (1011 square feet). The plaster soon became hard, and eventually could scarcely be scratched with the finger nail. At two places the plaster was too strongly heated and had to be renewed. In places where the plaster had become saturated with saltpetre, the varnish penetrated with difficulty, and in some cases even fell off in flakes after a time. In these cases it was necessary to renew the plaster. On new, dry plaster (gypsum, plaster of Paris) the operation was always successful. There can be no doubt that the flooring of basement rooms may be protected from damp in a similar manner. Where it is intended to put down an inlaid wood flooring, a layer of plaster should first be prepared, and be saturated with the mixture of oil and rosin: the parquetry can then be laid down upon this. For a stone flooring, the stone slabs or tiles may themselves be soaked with the varnish. And if this method is considered to be inadequate, there is another plan which is infallible for rooms which have an inlaid floor and are heated by a stove. A plaster sub-floor is laid down in the manner prescribed, and the air of the room is caused to traverse the space between this and the parquetry, on its way to the stove. Moreover, air may be allowed to enter from outside the house, and after passing, as usual, through the warming channels, be admitted to the room.

With regard to the above account, the author would most decidedly condemn the use of plaster of Paris (gypsum) as a cement for damp walls, for gypsum (hydrated sulphate of lime) is a salt soluble in 460 parts of water, and therefore in damp situations cannot fail to contribute to the formation of efflorescences, and consequently, on damp brickwork, affords a mortar which rapidly weathers and dissolves. Gypsum is therefore to be entirely avoided on damp walls, and its use as a mortar confined to dry localities, which are not exposed to rain or moisture. The solubility of gypsum is also considerably increased by an admixture of common salt (sodium chloride), sal-ammoniac (ammonium chloride), etc., one part of gypsum requiring only 122 parts of a saturated sodium chloride solution. The extreme susceptibility to weathering which is often exhibited by gypsum cement is probably due to the fact of its having been mixed with a water containing sodium chloride.

In the first edition of this work a material called tripolith was recommended: this is now found to consist of impure gypsum, mixed with clay, coke, and iron scale, and it has not fulfilled the expectations which were held with regard to it.

The following is quoted from a paper by Schneider in the *Building Trade Gazette* (*Baugewerks-Zeitung*) on a process for drying damp walls employed by him: "From a long experience I am assured that painting damp walls with any chemical preparation, or affixing to them any waterproof substance, such as lead paper, etc., never is, and never can be, attended with success, but generally helps to aggravate the mischief. Often indeed a satisfactory result seems to have been attained, but it is never lasting. The moisture contained in the wall, generally derived from the ground, is indeed at first prevented by the above means from reaching the surfaces, but is compelled to rise higher in the wall, and thus render the upper walls damp. And in a short time the efficiency of the applied material becomes exhausted, and the wall is damper than before." Schneider employs the following method: The cement covering the bricks is carefully removed from the interior surface of the damp wall. Oak trenails are then driven into the joints, at distances of 16 inches apart, and to these are nailed upright laths, 1 inch thick and $2\frac{3}{4}$ inches wide. To these are nailed in the horizontal direction laths 1 inch wide and $\frac{1}{4}$ inch thick, with interspaces of about $\frac{3}{8}$ inch. These laths are then plastered with a rather soft mortar, mixed with cow-hair, laid on about $\frac{1}{2}$ inch thick, and well pressed into the spaces between the laths: the surface is then smoothed with the float. The necessary circulation of air is provided for by boring holes in the skirting board.

According to the *Ungarischen Bauzeitung* (Hungarian Building Gazette),[1] the engineers in Szegedin, who required to dry some dwelling-houses which were standing in water, adopted the following method, which was recommended by a chemist in Buda-Pesth: "The wall is freed from its covering of cement, so that the bricks are exposed. These are thoroughly brushed down with a hard broom, and then coated with a material which is prepared as follows: A hundredweight of English tar is heated to boiling in an open vessel. Whilst keeping it boiling, $4\frac{1}{2}$ lb. of lard is gradually added, and when these are well mixed, 10 lb. of brickdust is added and is thoroughly stirred in. The fire is then lowered so that the mixture is just kept hot, and the wall is then tarred with it, and whilst it remains warm it is covered with dry river sand. As soon as the tar has become cold and hard it is coated with mortar. This method is very effective with the walls of ground-floor rooms. The above amount of tar will cover 322 square feet."

For drying damp cellar walls, Schmölke proposes to dig out a trench 2 to $2\frac{1}{2}$ feet wide down to the foundation level, so as to lay bare the cellar wall. The trench is then filled up with alternate layers of quicklime (12 inches) and coal ash (4 inches). The lime absorbs the moisture from the wall and surrounding soil, and forms with the coal ash a kind of concrete (*béton*), which then acts as a protection against the penetration of moisture. The employment of powdered quicklime by itself has also been suggested, as it absorbs and fixes in chemical combination any water with which it comes in contact. With regard to this process, which, although very old, is at the present time recommended as new, Dr. Runge in his *Elements of Chemistry* (Munich, G. Franz, pp. 284, 285) makes the following remarks: "If a lump of burnt lime is immersed in water and immediately withdrawn again, it will in a little while become hot and crumble to a dry white powder. This is called dry slaked lime. Although it appears perfectly dry, it has nevertheless taken up water, which it holds so firmly as to retain it when moderately heated. A red heat is required to drive off the water. This slaked lime is therefore a chemical compound, consisting of one combining proportion (56 parts) of lime and one combining proportion (18 parts) of water, and is known as calcium hydroxide.

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[1] *Ungarische Bauzeitung*, 1879, xvi. 129.

"The change which the lime undergoes after being dipped into water takes place also when lime is exposed to air. The lime absorbs the moisture from the air, and becomes the so-called air-slaked lime. At the same time it absorbs carbonic acid from the air, yielding a mixture of calcium hydroxide with calcium carbonate. It has been supposed that by means of this property lime might be used for drying damp buildings. But when it is considered that in this case the quantity of water absorbed would be quite insufficient to convert the lime completely into calcium hydroxide, it is clear that the process would prove ineffectual."

On other grounds also such an employment of lime is inadvisable. When it has been introduced into gunpowder mills to get rid of damp it has been found to be a serious source of danger, without accomplishing the desired end, since it does not absorb sufficient water. Consequently nobody need have any difficulty in forming an opinion on the value of lime as a drying material for walls.

From the following recipes for waterproof coatings, users can make their own selection.

Prosper Delatouche took out a patent in 1822 for a waterproof paint, composed of 8 parts of linseed oil, 4 parts of white lead, 4 parts of indiarubber, 1 part of pitch, 1 part of gum lac, 4 parts of train oil, and 2 parts of flake litharge. All these are mixed together, and the inner surface of the wall is painted with it. Delatouche remarks that this paint will only have the desired effect when it is laid on a perfectly dry surface.

G. Augustin (New York) has employed the following preparation: 70 grams of oak sawdust is exposed to the sun for twenty-four hours, then boiled with 4½ grams of linseed oil, 70 grams of rosin, and 18 grams of vitriol (probably white vitriol, zinc sulphate—Trans.) for half an hour, then mixed well with 280 grams of oil of turpentine and applied to the wall or the woodwork. Another waterproof material is obtained by boiling together in an iron pot, with continuous stirring, 50 parts of pitch, 16½ parts of rosin, 3½ parts of English red, and 7 parts of brickdust. About one-fourth of its volume of oil of turpentine is then added, and the mixture is laid on with a stiff brush.

Pflug & Co. of Kitzingen on the Main have for several years sent into commerce an oil paint (under the name "Platinanstrichmasse") for drying damp walls. This material is laid on like a paint; it has a beneficial effect only when the brickwork has previously been dried. (Pflug & Co. state that it serves both to protect from and to get rid of efflorescences and dry-rot, which is by no means the case.) A good waterproof material may be prepared by mixing at a moderate heat 4 parts of powdered glass, 3 parts of coal dust, 2 parts of powdered pumice, 3 parts of pitch, 2 parts of ship-pitch, and 1 part of boiled oil. After laying this preparation on the wall it is covered with sand in order that the cement with which it is to be coated may adhere to it.

W. Reiszig has obtained a German patent (Elsner's *Chemisch-technische Mittheilungen*, 1877–78, p. 38) for a paint for walls, ceilings, cellars, etc., which protects the walls from the penetration of water and other injurious liquids, prevents the growth of mould, and renders the wall washable with even boiling water. This is an alcoholic solution of sodium stearate, prepared by dissolving 50 parts of sodium stearate in 1000 parts of 66 per cent. spirit. Any alcoholic solution of soap may indeed be employed, but in cases where the cost is not the chief consideration sodium stearate presents the advantage that it forms a very hard and firm layer, which can be readily wiped clean with a dry cloth. For stables, a spirit solution of palm kernel soap or soft soap will suffice. The stronger the spirit the better. Alcoholic solutions of soap soak more deeply into the wall than aqueous solutions in consequence of the smaller decomposition of the soap. The solution may be coloured by adding dragon's blood, aniline dyes, or any pigment which does not decompose the soap, such as ochre, ultramarine, etc. For hospitals, antiseptics may be added, and this may also be sometimes done with advantage for the walls of stables. The soap solution should not be applied over oil paints, but answers well on wood, mortar, plaster, and cement. Distemper colours should first be fixed, for which purpose, besides the ordinary well-known means, a 5 per cent. solution of chrome alum may be recommended. Walls built of limestone may first be hardened with baryta water or water-glass (sodium silicate).

Attempts have been made to get rid of dampness in walls by giving a setting coat of cement mortar, or washing over with water-glass. From what we have said above, it is clear that these modes of treatment can by themselves produce no good effect. The cement mortar may prevent access of water, but cannot dry the wall. For the inner surface of the walls such a coat of cement should be avoided, as I have found in all cases where it has been employed that such walls always felt damp and cold, and that the incrustation of alkali salts which always forms to some extent on their surface has liquefied on the wall when comparatively small amounts of water have evaporated in the room, and has then produced wet spots again. Even more decidedly should the use of water-glass be rejected, since treatment with this substance is certain to intensify the evil, as water-glass does not harden or adhere except when the surface is dry. Water-glass cannot penetrate a damp wall so as to undergo decomposition in the pores of the wall; it therefore decomposes on the surface, the alkali forming an efflorescence and the silica a precipitate which does not adhere to the surface of the cement, but falls off. The evil has therefore been increased, and a still larger amount of hygroscopic salts introduced into the wall.

According to Ligny, the interior of a room, which it is desired to dry, should have the plaster completely removed from the wall at spots where it is damp or incrusted with salts, and all the joints carefully filled with fresh cement, as deeply as to half the thickness of the wall. To remove all saltpetre, the bare wall is then washed down repeatedly with water, drying it after each washing with Ligny's apparatus (see below, p. 41) and brushing it down with hard brushes. When the brickwork is thoroughly freed from salts and moisture it is warmed and brushed over with a boiling-hot mixture of linseed oil, rosin, litharge, and paraffin, which will now be eagerly absorbed. About 2 kilogs. of this mixture are generally required for each square metre (4 lb. per square yard). This operation is repeated until the brickwork will not absorb any more of the liquid. The whole is now left for several days to become completely dry; the joints are pointed with Portland cement, and a cement coat laid on, but only from the height of the base moulding, that is about four inches from the floor. The base of the wall is coated with a mixture of bitumen, pitch, and tar, which adheres better than cement, and presents the advantage of isolating the cement from moisture. Partition walls are to be treated on both sides in the manner prescribed, so that their plinths become impervious to moisture throughout the whole thickness. For front walls, Ligny employs this process generally only on the interior surface, but takes care that the exterior cement coat does not reach the soil, and that as far as damp has reached on the outside no oil paint is applied. The consequence is that the action of the external air suffices to prevent the moisture from extending.

J. Leber has patented a process for drying damp walls (German Patent, No. 3417, Class 37[1]). This process consists (1) in dispersing the moisture which shows itself on the surface of the wall, and (2) covering the wall with a preparation which absolutely prevents all interchange of liquid between the brickwork and the cement coat. This is effected in the following manner: The plaster is removed from the damp side of the wall, and the mortar cleared out from all the joints. The joints are then completely filled up with slag wool. The surface thus prepared is then covered with special plates, 25 cms. (10 inches) square, which are prepared as follows:—

A mixture is made of—

3 parts of galipot resin.
2 ,, mineral tar.
5 ,, asphalt (Val de Travers).
6 ,, clean dry quartz sand of moderate fineness.

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[1] *Illustrirtes Patentblatt,* 1880, vol. v. p. 378.

After these materials have been melted and well kneaded together, the mixture is poured into a mould of saw-shaped section. The flat surface is then lacquered with the following composition :—

2	parts of	Venice turpentine.
1	,,	shellac.
4	,,	spirits of wine.

The plates are then immediately strewed with fine but sharp sand, which adheres firmly, and to which the plaster which is laid over the plates attaches itself permanently.

The plates are affixed to the wall in the following manner : A mortar is made up with 4 measures of washed sand, 2 measures of hydraulic lime, and 1 measure of Portland cement. The ribs on the plates are so shaped as to give a good hold to the mortar, this being further assisted by the considerable quantity of quartz sand in the material of the plates. In attaching the plates to the wall, interspaces of $\frac{1}{8}$ inch are left, which are afterwards filled up with a cement consisting of 6 parts of rosin, 1 part of asphalt, and 2 parts of powdered lime, these materials being kneaded together hot, and the mixture pressed into the joints in a soft state. The material is allowed to stand out from the joints about $\frac{1}{12}$ inch, and is then driven in tight with a soldering hammer. The joints may also be brushed over with the varnish described above, and then sanded.

On the wall faced in this manner a finishing coat of plaster of Paris (lime-mortar is decidedly preferable to gypsum, for reasons already mentioned) is laid, and this may then be either painted or papered without risk of damage from the moisture in the wall.

Schwatlow, in Berlin, has taken out a patent (No. 4823) for the following method of obtaining a dry cement surface to damp brickwork, which is applicable to either old or new work.

"If an old damp wall is to be dried and recemented, in the first place all the old cement coat must be removed from the damp places, and for about a foot all round. After this, the process is the same for either old or new brickwork. The mortar is cleared out from the joints to a depth of an inch, and the well-swept and thoroughly wetted wall is thinly plastered with a cement mortar. Into this cement are pressed ordinary panes of window glass, either close together or with their edges overlapping. As soon as the glass plates are attached they are covered with about $\frac{3}{8}$ inch of strong cement. As the glass adheres firmly to the cement, and is in no way hygroscopic, even a damp wall will have a completely dry surface as soon as the cement has set, and there is no possibility of the damp escaping into the interior of the rooms."

We may here mention a plan recommended by M. H. G. Tölken "for freeing the air of a room from moisture in the winter time without opening the windows." He says, "nothing is wanted for this purpose but some sheets of porous paper, which are easily obtained. The matter may surprise some people, but it is, nevertheless, based on sound scientific principles. The breath of men and animals is loaded with moisture. If this is doubted, let anyone breathe upon a cold object, such as glass or iron ; the object will soon become wet by condensing the aqueous vapour in the breath. Now our dwelling-rooms are full of damp air, resulting from the expirations of their inhabitants, and this is most noticeable in cold weather. When the window panes become cooled by the low temperature outside, they cool the damp air of the room which is in contact with the glass, and the moisture condenses and settles on the glass. So much moisture has been removed from the air of the room. Let now the windows be wiped down with a sheet of waste paper, and, when the paper is soaked, let it be thrown out of window. If it is kept in the room all the trouble will be thrown away ; for the water in the paper will again be evaporated by the heat of the room, and will return to the air of the room. By wiping down the panes of glass with fresh dry paper every quarter of an hour the air of the room will soon become drier, and will consequently appear warmer."

CHAPTER IV.

THE ARTIFICIAL DRYING OF NEW HOUSES, AS WELL AS OLD DAMP DWELLINGS, AND THE THEORY OF THE HARDENING OF MORTAR.

FOR drying new houses and damp dwellings, or walls which have been coloured by the stereochrome or Keim's method, one should choose, as far as possible, the most favourable time of year, the driest days, and the best and most suitable modern appliances, since attention to these points will bring about the desired result in the quickest and most satisfactory manner.

Pierro and Dehaitre, in the *Revue Industrielle,* in an article "On Artificial Drying in General, and the Methods of Drying Fabrics," remark that it is a common error to suppose that heat alone is sufficient to produce drying, and that renewal of the air is unnecessary. It is, on the contrary, the latter which causes the drying; the function of the heat is only to produce the most favourable conditions for the action of the air. They remark, further, "According to the temperature, and the previous hygroscopic condition of the air, varying quantities of water will be taken up in the vaporous condition : thus a cubic metre at 20° C. will take up 16 grams, but at 80° 200 grams of water. It may be looked upon as a vehicle which enters the drying-room empty, gets filled with water vapour, and when it has reached its degree of saturation must again be removed.

"A continuous, accurately regulated air current is therefore the most advantageous for drying. The employment of warm air in this operation may be compared with that of water in washing. The one operation begins with dry air, the other with clean water : the former must be removed as soon as it is damp, the latter as soon as it becomes dirty."

In the drying of dwelling-houses, frescoes, etc., scarcely any attention has been paid to these conditions, and I have gained abundant experience in this direction in fixing wall paintings in cases where the operation has had to be performed without suitable drying apparatus in damp, cold weather, as at the Isarthor and in the arcades of the Palace Gardens in Munich. For instance, in 1892, from 24th to 26th October, when fixing the fresco "The Coronation of Ludwig the Bavarian" in the Royal Palace Gardens at Munich, I had numerous observations taken of the temperature and humidity of the air by Dr. Erk. The same elements were simultaneously determined in the recesses where the frescoes are situated. Dr. Erk remarks that on the one hand some interesting results for technical purposes were obtained with reference to the instrumental appliances employed, and, on the other hand, the observations showed how much the humidity of the air might vary, not only with the time of year, but even from day to day. He further points out how insignificant the drying effect of the open air may be when the weather is unfavourable, in spite of efforts to raise the temperature.[1]

Pierro and Dehaitre continue as follows : "It is especially important, when drying a wall, to observe the state of the outside air. If this is dry, as in summer, the operation proceeds very rapidly; rain or mist, on the contrary, hinders it seriously. In order to secure rapid drying at any season, special arrangements must be made to supply air with a constant evaporating efficiency. This result is obtained by the use of special drying machines." The authors had an apparatus of this kind constructed, which kept the temperature at 60° C. and required only one-eighth of the quantity of air which would otherwise have been necessary.

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[1] See "Bemerkungen über die Temperatur und Feuchtigkeitsverhältnisse der Aussenluft unter besondere Berüchsichtigung ihres Einflusses auf die Mauerfeuchtigkeit" (Remarks on the Temperature and Humidity of the Atmosphere with Special Reference to its Influence on the Dampness of Walls), by Dr. Erk, Munich, *Technische Mittheilung für Malerei*, 1893, No. 161, pp. 216-220 ; No. 162, pp. 234-237.

On the "Artificial Drying of New Structures," see a report by V. von Novelly in the *Neue Freie Presse* of 4th Sept. 1888, No. 8632, on designs for this purpose, shown by M. L. Kruse of Copenhagen at the Brussels International Exhibition for Hygiene and Life Preservation. The principle of the method is the establishment of a central furnace for all the rooms to be dried, and a vigorous ventilation. Novelly employed this method with satisfactory results even in persistently wet weather, by conducting the air through wooden channels filled with calcium chloride. A fortunate chance allowed the cost of this work to be compared with an analogous case in Vienna, in which the drying was carried on with a brasier fire, and where the building had a capacity of 3400 cubic metres, whilst that operated on by Novelly was of 3425 cubic metres. The cost of the latter amounted to 1180 florins, that of the former to 2090 florins, a proof how much economy may result from a rational method of drying, independently of the thoroughness of the result. The drying in both cases took twenty-nine days.

The following report is taken from Dingler's *Polytechnisches Journal* on a process employed by Ligny for drying damp walls.[1]

The system in question, which has been in use for ten years with the best results, embraces the rapid drying both of new dwelling-houses which it is desired to occupy immediately, as well as of old buildings whose basements have become uninhabitable in consequence of the walls having absorbed damp from the soil.

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[1] Dingler's *Polytech. Journ.*, 1876, vol. ccxxii. 342.

THE DRYING OF NEW BUILDINGS.

The requisite appliances are (1) a wheeled truck on which the apparatus can conveniently be moved to any situation in the room which is to be dried, (2) an ash-tray resting on this truck, (3) a rectangular iron fire-box, 28 inches long by 16 wide and 16 high, filled with coke, and with a sheet-iron screen which serves as a reflector, (4) a funnel-shaped iron cover to the fire-box and six lengths of sheet-iron flue, 3 feet 6 inches to 4 feet long, which can be joined together as desired to convey the heat of the fire to any part of the room, and which are supported by iron clamps attached to the fire-box.

When the apparatus is heated, the cold damp air of the room passing through the fire is deprived of its moisture,[1] and at a very high temperature is directed against the walls. The windows should be open during the operation, and the air of the room will acquire a temperature of 30° to 35° C. If necessary, there may be a small ventilator in one of the flues, to allow a larger volume of hot air to be thrown upon a given point, or to reach a position to which the apparatus cannot be brought sufficiently near. By increasing the size of the apparatus the drying will be accelerated ; a room can be dried in four or five days, or, if requisite, even more quickly.

Very serviceable also for the drying of both new and old buildings is the Kosinski process, which was applied with excellent results to the drying of the Grand Hotel in the

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[1] This expression in the original indicates that the author is not free from the popular error that heating air dries it. The actual amount of water in the air is not diminished by raising its temperature ; but since the capacity of air for absorbing moisture is increased by rise of temperature, the relative humidity or proportion of total saturation is diminished.—Note by Translator.

Alexander Platz, Berlin, in 1884 (*Bautechnische Rundschau*, 1884, No. 17). Kosinski gives the following account of his process in the German patent, No. 40,852: "A reasonable arrangement for heating, drying, ventilating, and disinfecting rooms, requires not only that the air of the rooms should be warmed to and maintained at the desired temperature, but also that the carbonic acid gas which is unavoidably produced should be removed as rapidly as possible, since it is both injurious to human beings and hinders the escape of water vapour from freshly built walls. Moreover, a regular circulation of air should be established, so that the air saturated with water vapour may be automatically removed, and fresh air be brought in to be heated." The patent specification proceeds: "For drying new buildings, and for disinfecting the same, it is necessary to have apparatus which will produce high temperatures, and it is specially important that the carbonic acid should not come in contact with the walls or with the objects which are to be disinfected, since on the one hand it hinders the escape of moisture from the interior of the brickwork, and on the other favours the production of bacteria. It is, moreover, necessary that the air which is saturated with moisture should be removed and replaced by fresh air," etc.

The patent claim runs thus: "For the drying, ventilation, or disinfection of rooms by means of a heating apparatus, in such a manner that the air for the combustion is drawn in from outside the house, and the products of combustion are also carried into the outer air by flue pipes, whilst the air required for ventilation, etc., is separately introduced from outside in such wise that it does not come in direct contact with the fuel, but receives its heat entirely from the walls of the heating apparatus, and after taking up the substances which are to be got rid of, falls to the ground as it cools and is carried away to the outside by the suction of the products of combustion escaping through the smoke flue of the heating apparatus."

For assisting the drying process, especially in new brickwork, and for the rapid conversion of the hydrate of lime in the mortar into carbonate, A. C. P. Schmidt of the Martinikenfelde, near Berlin, recommends his chemically prepared "Press-holzkohlen-Trocken-Briquettes." With these, the still damp new brickwork, or any old damp building, after access of air has been reduced as far as possible, is dried and carbonated. These briquettes are not intended to take the place of the coke brasier, but only to supplement its effect by the evolution of larger amounts of carbonic acid gas. Since, however, the coke brasier already produces more carbonic acid gas than is necessary, as is quite correctly stated in Kosinski's patent, this material is quite superfluous, and is only alluded to here for the sake of completeness. See also the remarks on Glässgen's experiments on the drying of mortar (p. 49).

For drying single rooms which have already been painted and papered, Ernst Nöthling recommends various forms of stoves for burning spirit, gas, or petroleum. He also suggests, for getting rid of damp and bad smells, that trays filled with small pieces of quicklime, and others containing powdered wood charcoal, should be placed on the floor. Chloride of calcium and chloride of lime would have a similar action.

The water which deposits on the windows during the drying of a room should be wiped off with rags or absorbent paper, which should then be removed from the apartment that the water may not evaporate there again.

In Dingler's *Polytechnisches Journal* for 1900, vol. cccxv. part 11, there occurs a notice of the most important novelty in the drying of buildings. This is the process of the Government Architect, Seemann, which at the present time has been brought into use on the large scale for the drying and disinfection of buildings by the "Bauhygiene" Society in Berlin.

The apparatus employed (see Figs. 3 and 4) is capable of forcing, by a revolving fan, several hundred cubic metres of air

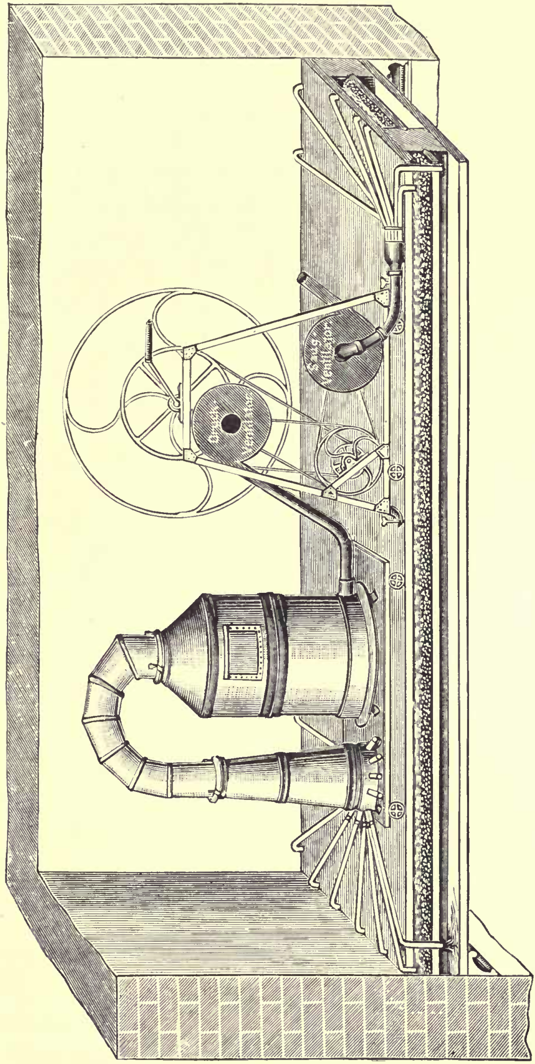

FIG. 3.

heated to 200° C. into the space below the floor boards of a room. This heated air becomes saturated with the moisture which it meets with under the floor, and is then drawn out by a second ventilating fan. A very thorough aëration of the whole space is thus effected, and any of the woodwork which, in consequence of the presence of moisture, has a tendency to encourage fungoid growths, and which, owing to the want of natural ventilation, cannot dry spontaneously, is by this means completely dried and disinfected without the necessity of lifting the floor boards. In specially difficult cases the heating action of this apparatus can be assisted by using hanging furnaces of special construction. A further novelty, by which massive walls of any thickness can be dried, is a fire-box with air-blast. The fire-box consists of a sheet-iron case with a grate, about one metre in length, and open at the upper part in such wise that the flame from a wood charcoal fire is driven by a blast against the wall. See Figs. 5 and 6.

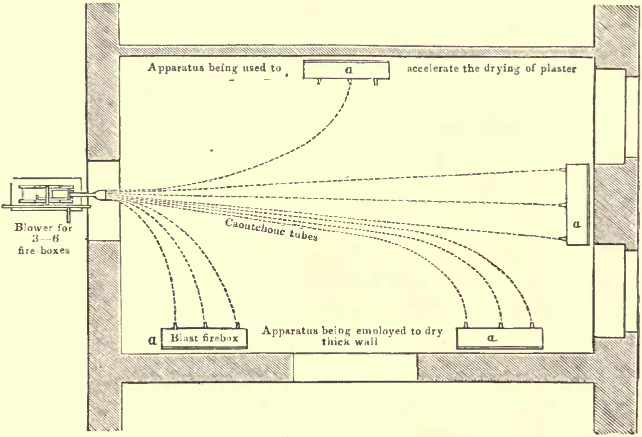
Apparatus being used to
a
accelerate the drying of plaster
Blower for 3—6 fire boxes
Caoutchouc tubes
a
a
Blast firebox
Apparatus being employed to dry thick wall
a

FIG. 4.

The area of the wall which becomes dried is considerably larger than the portion exposed to the direct action of the fire;

but by using several of these fire-boxes simultaneously, several walls may be dried at once. This blast apparatus has a much more intense heating action than the ordinary coke brasier, its effect reaching quite through even thick walls; and, unlike the brasier, from which much of the heat rises uselessly to the ceiling, its action is applied exactly where the drying is required. These blast fire-boxes are especially adapted for drying cellar walls and thick walls which have not dried naturally. They have recently been employed at the Charlottenburg Palace for drying damp walls built of porous, absorbent materials, about one metre thick, prior to forcing tar into the dried stratum of the brickwork, by means of holes bored

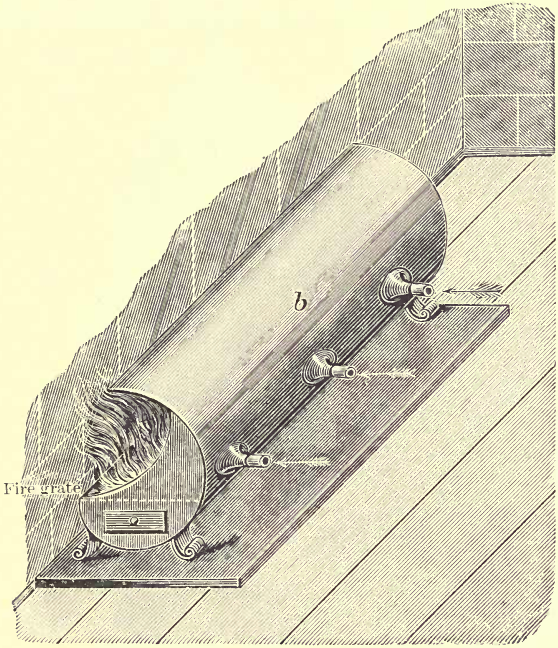

FIG. 5.

through the wall. In this way a horizontal damp-proof course has been produced.

This process has been employed by the "Bauhygiene" Association with excellent effect in some difficult cases. Thus, 8 to 10 square metres (86 to 108 square feet) of walls 29 to 51 cms. thick (11 to 20 inches) have been dried in ten hours, whilst a superficial area of 20 to 30 square metres (215 to 320 square feet) of wall plaster has been dried in the same time. By this process the problem of an efficient mode of drying seems to have been practically solved, and even Kosinski's apparatus has been far surpassed.

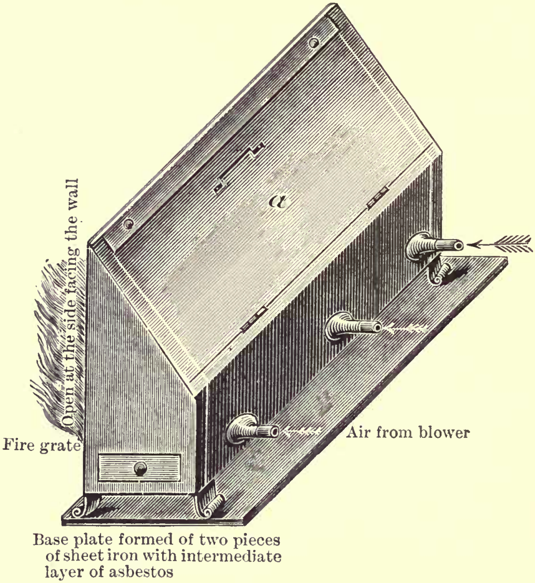
Open at the side facing the wall
a
Fire grate
Air from blower
Base plate formed of two pieces of sheet iron with intermediate layer of asbestos

FIG. 6.

A mining engineer named Ludwig Zechmeister, of Munich, has also successfully occupied himself with the drying of damp walls and the destruction of the nitrifying organisms contained in them, and has constructed an apparatus for this purpose, which has given good results. But of this process I have been unable to obtain particulars.

It must, however, be here remarked, that the rapid drying of new buildings ought not to be undertaken without due consideration. In old buildings, in the mortar of which the calcium hydroxide (hydrate of lime) has been completely converted into carbonate, and the mortar has attained its full hardness and binding power, rapid drying, or the removal of the water mechanically held by the brickwork, is permissible by any of the above processes. But the case is far different with new brickwork, with fresh mortar which has not yet attained its full hardness, since by removing too rapidly the chemically and mechanically combined water,[1] and by carbonating the lime too quickly, only a friable mass, destitute of cohesive strength, would be produced. Not only ordinary lime mortar, but all kinds of cement mortar, must be allowed to harden completely before any process of artificial drying is applied. Serious errors are even now committed with regard to this matter, although the theory of the hardening of mortars is extremely simple, clear, and intelligible. Pure plaster of Paris forms an exception; this, when it has once solidified, is in no way injured by rapid drying.

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[1] "On the Amount of Water in Walls," Dingler's *Polytechnisches Journal*, ccxvi. 186.

Glässgen (*Zeitschrift für Biologie*, 1874, 246) has made numerous experiments on the question of the degree of dryness or dampness at which a new house can be pronounced "dry" enough to be inhabited without danger to health. The material selected for the experiments was the plaster from the inner surfaces of the walls, which, being in intimate contact with the brickwork, was assumed to have the same degree of dampness as the latter. Both the free water and that in combination with the lime (as hydrate) were accurately ascertained by analysis. With this object samples of the mortar from various parts of the wall were taken and preserved in well-stoppered bottles. Each of the samples was passed through a sieve (with meshes $1\frac{1}{2}$ mms. square) and 25 grams of the sifted substance were placed in a Liebig's drying tube, which was then heated, whilst air, purified from water and carbonic acid, was passed through it. The operation was at an end after three-quarters to one hour, and the loss of weight of the drying apparatus gave at once the proportion of free water contained in the pores of the mortar. For estimating the combined water, a current of carbonic acid gas was now passed over the dry mortar whilst warming. From the gain in weight, the amount of calcium hydroxide can be calculated. By this method the percentage of water in the mortar of a number of new houses was ascertained at various times, with the result that a continuous decrease in dampness occurs as time elapses, the rate being greater in summer than in winter, and also greater in a detached house than in one not detached. The author considers that one per cent. of moisture in the mortar must be taken as the limit.

My personal experience with regard to the preparation of wall surfaces for painting on has convinced me that the layer of stucco employed as the ground to which the paint is to be applied generally becomes dried too rapidly if prepared in summer. In almost all the specifications of architects for plaster mouldings, projections, etc., provision is made for a coat of cement only $\frac{1}{2}$ to 1 cm. ($\frac{1}{5}$ to $\frac{2}{5}$ inch) in thickness, which, at the time of year when such work is generally executed, loses its water completely in a very few hours. Such a layer of stucco never becomes thoroughly hardened, but forms only a coating which rapidly weathers and scales off, and is therefore quite unfit for the application of decorative paintings. In fact, the more solid the coat of paint, the harder it becomes, and the more it tends to shrink in drying, the greater is its tendency to flake off, bringing away the stucco with it.[1] In such a case as this the failing is usually attributed to inferiority in the quality of the stucco or paint, whereas in reality it is wholly due to an incorrect and irrational employment of the materials. The theory of the hardening of mortar, consisting of hydrate of lime, sand, and water, is as follows

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[1] Neither the painter nor the plasterer can alter these facts, but simply have to accommodate themselves to the circumstances. The mischief could only be prevented by prolonging the time during which the stucco has an opportunity of hardening by wetting the surface two or three times each day. But, as a rule, the plasterer is indifferent to the trouble which the painter may meet with later on.

(Gottgetreu, *The Physical and Chemical Nature of Building Materials, etc.*):—

"If freshly mixed mortar is left exposed to the air for only a short time, it becomes covered with a thin skin; this skin consists of calcium carbonate, which has been precipitated by the action of atmospheric carbonic acid on the solution of calcium hydroxide contained in the mortar.[1] The action takes place in accordance with the equation: $Ca(OH)_2 + CO_2 = CaCO_3 + 2H_2O$. This film adheres very firmly to the surface of the sand grains, as well as to those of the bricks. The precipitate of calcium carbonate from a solution of calcium hydroxide seems to be in a very impalpable form. Crystals are not discoverable in the precipitate.[2] Its adhesion to the surfaces on which the precipitation takes place is, however, very great; this is especially the case with bricks which have a very porous surface, because the calcium carbonate penetrates into these pores as it forms. This accounts for the rapid binding which is observed in putting up brickwork, as soon as the individual bricks are set in the mortar." (It is, however, partly due to the rapid removal of the water from the mortar by the bricks, which are highly absorbent.—Note by Author.)

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[1] Wolter has shown by numerous experiments that the absorption of carbonic acid by fresh mortar takes place more readily from atmospheric air than from pure carbonic acid gas itself; further, that fresh mortar absorbs scarcely any carbonic acid, etc., and that a simple paste of slaked lime behaves in a similar manner. The absorption of carbonic acid by mortar therefore occurs during the drying. A mortar which had set so far as to contain about three-fifths of its original water, had absorbed about four times as much carbonic acid as undried mortar during an equal time, but only under circumstances which permitted further drying. If the conditions did not permit this, the material behaved like fresh mortar, etc.

From these and other researches the author infers that freshly mixed mortar, containing a full proportion of water, absorbs only traces of carbonic acid, not exceeding one-third per cent., and that the main absorption takes place as the mortar dries, being very slow if the drying is slow, but more rapid if the natural drying of the mortar is quicker. Even mortar which has set (and contains five-ninths of its original water) exhibits the same behaviour, although the absorption takes place somewhat more rapidly in the early stages. The absorption of carbonic acid never takes place more quickly than the evaporation of the water, and is essentially dependent on the proportion of water present. See H. Zwick, *Kalk-und Luftmörtel*, p. 185 (Vienna, 1879, A. Hartleben).

[2] According to other writers, the hardening of mortar is essentially due to the formation of minute crystals of carbonate of lime (calcspar).

As long as there is sufficient water in the mortar, this continues to dissolve the calcium hydroxide as fast as the latter is converted into calcium carbonate, and as fast as carbonic acid from outside obtains access to the calcium hydroxide solution (lime water), calcium carbonate is precipitated. The formation of calcium carbonate and the hardening of the mortar proceed therefore from the outside inwards. At the same time as the formation of calcium carbonate, evaporation of water from the mortar goes on. The rate at which this takes place has a large influence on the further hardening of the mortar. If the evaporation takes place with great rapidity, and the process of solution of the calcium hydroxide is no longer able to go on, the carbonic acid of the atmosphere penetrates into the pores of the mortar and combines directly with the solid calcium hydroxide present in the mortar. This combination of carbonic acid with the solid calcium hydroxide does not essentially assist in hardening the mortar. The moment when this action begins to occur is that at which the hardening of the mortar ceases. When this is complete—and this takes place very rapidly as soon as no more moisture remains—the mortar will have become an inert mass, in which the characteristic binding action can no longer go on. If, however, the evaporation of the water in the mortar takes place slowly, from within outward, and only through a restricted surface, and if, consequently, the solution of the calcium hydroxide and precipitation of the calcium carbonate are spread over a long period, so that the greater part of the calcium hydroxide present passes through the state of solution, such a mortar will be incomparably harder. Under favourable circumstances it is therefore possible for a simple lime and sand mortar to form a very strong cement.[1] From the above considerations it is evident that mortar dried artificially, or too rapidly in any way, will have but little coherence, but will crumble like dry sand, and that consequently brickwork either artificially dried or built up during very hot weather, especially if in the form of thin walls,[2] will not have much strength. The same will be the case with brickwork in the building of which an insufficient quantity of water has been used. On the other hand, thick walls, or those built in mild weather, and in which an ample quantity of water has been used, will be much stronger. Also brickwork below the ground level, although attaining its hardness later, will be stronger than that built under equal conditions above the surface of the ground.

Therefore, before proceeding to dry a new building by artificial means, it is necessary to ascertain whether the mortar and plaster have hardened to a sufficient extent, so that their strength may not be injuriously influenced by the rapid drying. As already remarked, these considerations do not apply to old brickwork.

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[1] On the theory of the hardening of mortar, see further the views of Prof. Dr. Hans Hauenschild in the *Handbuch der Architektur* of Dr. Durm, 2nd ed. part i. chap. iii. pp. 132–134, 137, 138, "Mortar and Mortar Materials," Darmstadt, 1895; and Dr. Košmann in the *Thonindustriezeitung* for 1897, No. 31.

[2] Or thin coats of stucco or cement laid upon dry walls in hot weather.

CHAPTER V.

NEW, CERTAIN, AND PERMANENTLY EFFICIENT METHODS FOR DRYING OLD DAMP WALLS AND DWELLINGS.

BEFORE proceeding to the special operations for drying an old piece of brickwork, it is necessary to carefully consider the local circumstances and the cause of the dampness as accurately and completely as possible. Having done this, the rules which will be laid down farther on may be adopted to prevent future access of moisture. Then, from the inner side of the damp wall in question the plaster is removed for a space of two or three yards round the damp places, or, better still, from the whole surface of the wall, and the mortar is cleared out from the joints to a depth of half an inch. If none of the drying apparatus already described are available, one or two fire-baskets (Figs. 7, 8, and 9), according to the size of the place, must be provided. Each of these holds from 40 to 80 lb. of coke, and being filled with burning coke they are employed for heating the place. They should not be introduced into the room until they have ceased to give off smoke and the coke is in a thoroughly glowing condition. Doors and windows should be kept shut, to retain the heat in the room. Attention should also be given to the considerations advanced in the preceding chapter relative to the hardening and drying of mortar.

As soon as the condensation of moisture on the windows becomes considerable, doors and windows are opened to establish a draught and remove water vapour. Care should be taken to hold the breath on entering the room, so as not to be affected by the gases (carbonic acid and carbonic oxide) present. As soon as the water vapour has been removed, and the atmosphere of the room replenished with air for the combustion of the coke, the windows and doors are again closed. The heating, with alternate opening and closing of the apertures, is to be continued, until finally, even after two or three hours' heating, no condensation of moisture takes place on the colder parts of the chamber. One may then feel certain that the walls have become thoroughly dry, and that no more calcium hydroxide is present in the mortar. Even in the most unfavourable cases this operation does not last more than two or three days, and a result is reached which at ordinary temperatures might require months. By this treatment, not only will the brickwork have become thoroughly dry, but if the mortar

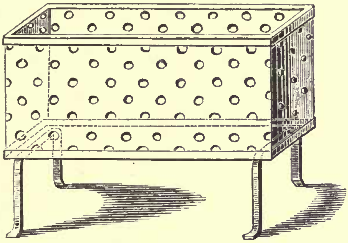

FIG. 7.

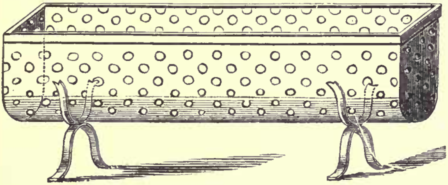

FIG. 8.

has not previously been completely carbonated, this will also be effected, and an increase in the porosity of the wall, which allows the diffusion of air to take place through it, will also have been obtained.

Where the apparatus of Kosinski or Seemann is available, it is, of course, to be preferred to the simple fire-basket.

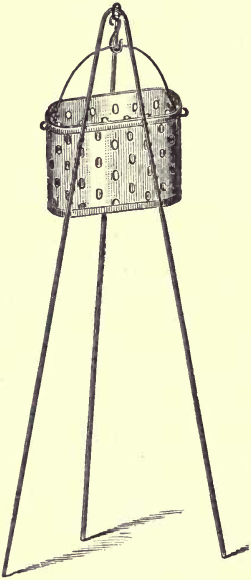

FIG. 9.

When, by any of these methods, the drying of the walls has been accomplished, the wall should then be covered on its inner side with an isolated layer of tiles or of wood. At distances of about 20 inches (according to the size of the tiles) oak trenails are driven into the joints of the brickwork, and to these upright battens, $\frac{3}{4}$ to $1\frac{1}{2}$ inch thick (Fig. 10 *a a a*)[1] are nailed, and are still further secured by wall hooks. To preserve the battens from rotting they should be well dried and coated with water-glass mixed with red colcothar, or, better still, be treated with carbolineum.[2] Against these battens the tiles (Fig. 10 *b b b b*) are then fastened with cross-headed nails, leaving a space between the wall and the tiles, which is then to be loosely filled with well-

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[1] EXPLANATION OF FIG. 10.—This represents a wall which is to be dried; part of it is shown in a finished and cemented condition.

a a a. Battens fixed to the wall for supporting the tiles; their thickness determining the width of the space to be filled with kieselguhr.
b b b b. Clay tiles.
c c. Nails for fixing the tiles to the battens.
Line 1—1. Kieselguhr packing.
,, 2—2. Part of the wall not yet covered with tiles.
,, 3—3. Part of the finished and plastered wall.

Fig. 10*a* is a sectional view of Fig. 10 through the line 4—4.

[2] See p. 107.

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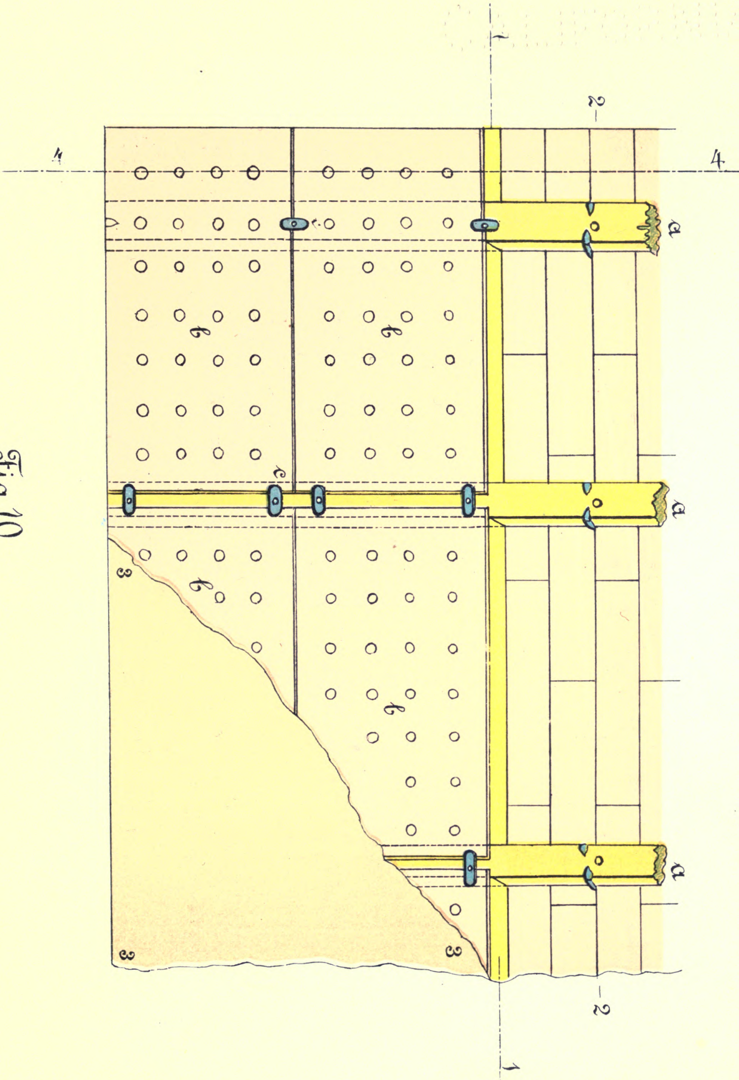

Fig. 10.

PREVENTION OF DAMPNESS IN BUILDINGS.

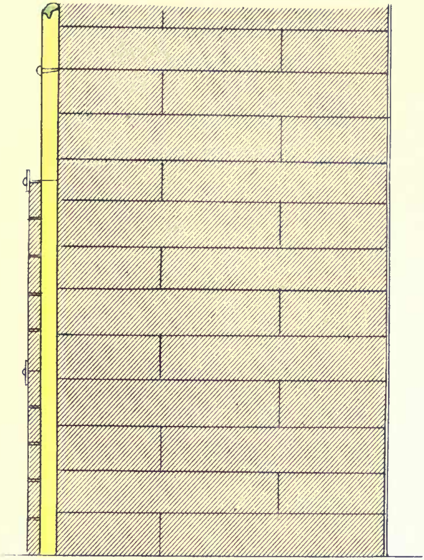

Fig. 10a.

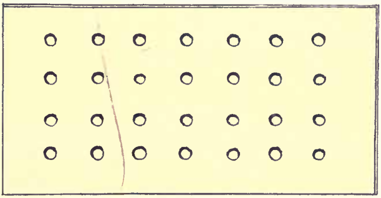

Fig. 11.

dried infusorial earth (kieselguhr) (Fig. 10, line 1—1). The tiles (Fig. 11) are 20 inches long and 10 inches wide and are $\frac{3}{8}$ to $\frac{3}{4}$ inch thick. To preserve the shape of the tiles during the baking, and also to give a hold to the coat of plaster which is to be laid over them, they should be pierced with a number of holes about $\frac{1}{8}$ inch in diameter. The tiles themselves should be made porous, by forming them of loam mixed with powdered charcoal, sawdust, or some such substance which will burn away during the firing.

If there is no necessity for the greatest possible economy of space, hollow bricks (Figs. 12 and 13) may be made use of, an independent wall or casing being built up with these, and the space behind filled up with infusorial earth (Fig. 14, line *a*). A casing constructed of these hollow bricks is not more expensive than one composed of tiles. This casing is then to be coated with ordinary wall-plaster, which should be made with well-tempered lime and washed sand, so as not to introduce any hygroscopic salts into the wall. The plaster may then be dried and carbonated in the same manner as the wall itself, only not too quickly.

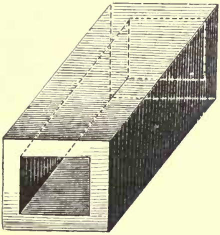
FIG. 12.

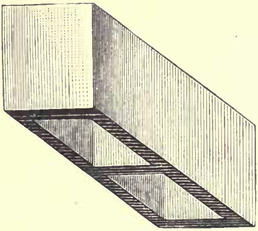
FIG. 13.

With regard to the material which is here advocated for filling up the space behind the casing, the following remarks will be of interest:—

Infusorial earth (kieselguhr), which consists of the skeletons of the microscopic plants known as diatoms, is almost pure silica. It is very light, is incombustible and infusible, and at ordinary temperatures is not attacked by acids or alkalies.[1]

Infusorial earth, on account of its power of absorbing liquids and its low heat conductivity, finds the most varied industrial applications.[2] It is especially suitable for absorbing large

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[1] Prof. Hausmann, in a report to the Royal Society of Sciences at Göttingen (*Göttinger Gelehrten-Anzeiger*, 1833, parts 14 and 15) on two specimens of earth forwarded to him from the Principality of Lüneburg, says, "The extreme lightness of these specimens rendered it highly improbable that they were of a clayey nature; whilst their consistence did not indicate that they were composed of silica, which nevertheless was found by chemical analysis to be the case. Specimen No. 1 is chemically pure silica. It has a fine, loose, flocculent consistence, with a soft, starchy feel, and is not gritty between the teeth. Thrown upon water it floats for a moment, then sinks to the bottom and gradually swells up. Mixed with water it assumes a starchy consistence, but without becoming plastic. Specimen No. 2 is also silica, with an inconsiderable proportion of combustible matter. It has a fine earthy fracture, and is of brownish grey colour with a greenish tinge, which colour becomes darker on wetting it. It is friable, meagre, but soft to the touch, and adheres to the tongue. It floats on water for a few moments, then sinks to the bottom, absorbing water and giving off air bubbles; it then gradually exfoliates, but without entirely opening out. After heating to redness it becomes quite white. Further examination showed that both specimens consisted entirely of infusorial skeletons, of which there were many varieties present, but all of known and recent forms. According to Dr. Runge, a cubic inch of kieselguhr contains 47 millions of these skeletons; other writers state that 187 millions of them would only weigh 1 grain."

[2] On account of its capacity for absorbing liquids, and its insolubility in acids and alkalies, it is much used for cleansing basins, flasks, etc., and for soaking up liquids which have been spilt. After allowing it to dry, it is again fit for use. Shaken with an alcoholic solution of an aniline dye, then thinned with water and thrown on a filter, it retains the dye and gives a colourless filtrate (*Neueste Erfindungen und Erfahrungen*, 1874, p. 460; 1876, p. 436).

In the Official Report on the International Exhibition of 1873 at Vienna, Dr. Hofmann remarks (p. 679: Vieweg & Son, Brunswick), "According to all appearance, the quarrying of kieselguhr is becoming an important branch of industry. As an incombustible and very voluminous substance it is especially suitable for many technical applications. It is an almost perfect non-conductor of heat, and is by far the best material for packing steam boilers and all similar purposes." It is used for packing ice-houses and ice-safes.

Infusorial earth is also employed for the manufacture of water-glass and of ultramarine, in both cases replacing the quartz sand hitherto used. Its employment in making dynamite is well known.

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Fig. 14.

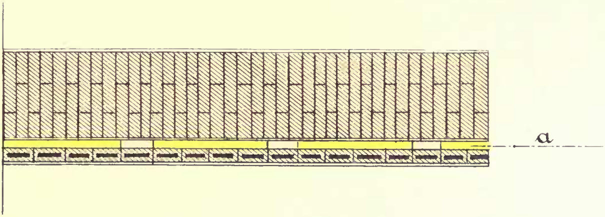
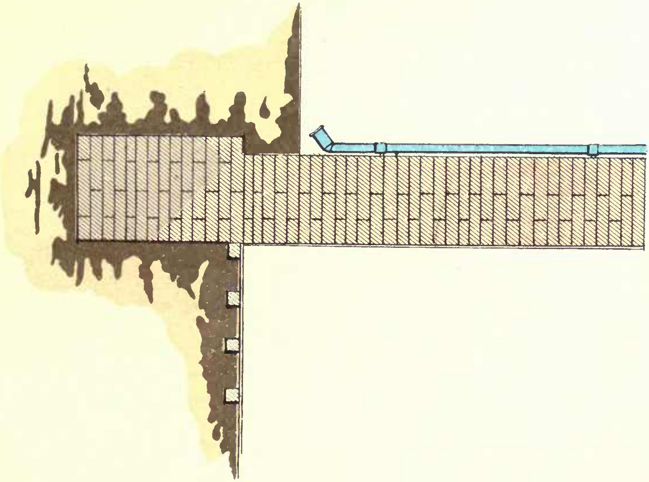


Fig. 15.



quantities of water, which it retains until warm weather brings about the conditions for drying it again. It is capable of absorbing four to six times its weight of water; with three times its weight of water it does not even feel damp. In this respect it far exceeds burnt clay, pumice, charcoal, coal dust, etc. Its efficiency for the purpose for which it is here recommended depends on this capacity of absorbing moisture by capillary attraction, and retaining it until the return of dry weather causes it to give up the moisture which it has absorbed. Since it keeps in a dry condition both the brick wall and the inner casing of tiles, and rapidly attracts any wet which falls upon them, it is a very effectual means of drying the room, and even the exterior wall, if a stop is put to the rise of ground moisture.

For a space 2 cms. ($\frac{3}{4}$ inch) wide there will be required about $6\frac{1}{2}$ kilogs. of infusorial earth per square metre (12 lb. per square yard), and since this can take up three times its weight of water without being saturated, it follows that to exhaust its power of absorption there must be at least 20 kilogs. of water in each square metre of wall surface. Such a quantity of water is not present in the dampest wall; and since, as we have remarked, the kieselguhr from time to time parts with the water which it has absorbed, there can at no time be the smallest doubt as to its efficiency.[1]

There remain to be considered the requisite measures for preventing the access of water to the brickwork. These would include means of counteracting all mischief arising from roofs, gutters, drains, etc., protective measures against floods, provision for the rapid removal of rain and snow, and lastly, means of preventing the rise of ground damp. It is with the last only that I consider it necessary to deal here, as all the others can be easily obviated.

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[1] See H. Zerenner, *Beitrag zur Kenntniss und Verhütung des Hausschwammes, etc.*, p. 23. E. Baensch, junior, Magdeburg, 1877.

The precautions to be taken against the rise of ground damp in old buildings may be divided into operations inside and operations outside the building.

1. OPERATIONS INSIDE THE BUILDING.

If in the building to be dried there are no cellars (Fig. 15), a plank of the flooring should be raised and the material underneath examined. (Fig. 15 represents the wall of a basement apartment which it is desired to dry; the floor of the room is below the street level, and there are no cellars to the house.) If this is found to be wet, or if it is moist vegetable soil, the whole of it should be removed to a depth of 0·6–0·8 metre (24–32 inches). A layer of concrete (see Chap. II. p. 15) should then be put in, and above this a stratum of coarse dry gravel up to the level of the joists (Fig. 16); the latter, however, should be imbedded in dry kieselguhr (Fig. 16, line *a*), with which also the whole space up to the floor boards should be filled.[1] The walls are then to be dried as described above, and the floor boards relaid. If, however, an excessive amount of ground moisture is present, the plaster should be removed from the whole of the brickwork down to a few inches below the level of the floor boards (Fig. 16, line *b*), and the foundation walls coated with glazed tiles; the isolated places are then also closed in with good bricks and hydraulic mortar. These operations have to be performed on all the four outer walls. This method being somewhat inconvenient, expensive, and applicable only to thin walls, I have often advocated the following alternative: The surface of the brickwork is cut away to a depth of about 5 inches and to a height of several feet; a false wall is then built up with good bricks (Fig. 16,

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[1] The London Building Act, 1894, prescribes that there shall be a sufficient space between the ground and the floor surfaces to admit of ventilation. Local building bye-laws generally lay down definite dimensions for this air space.

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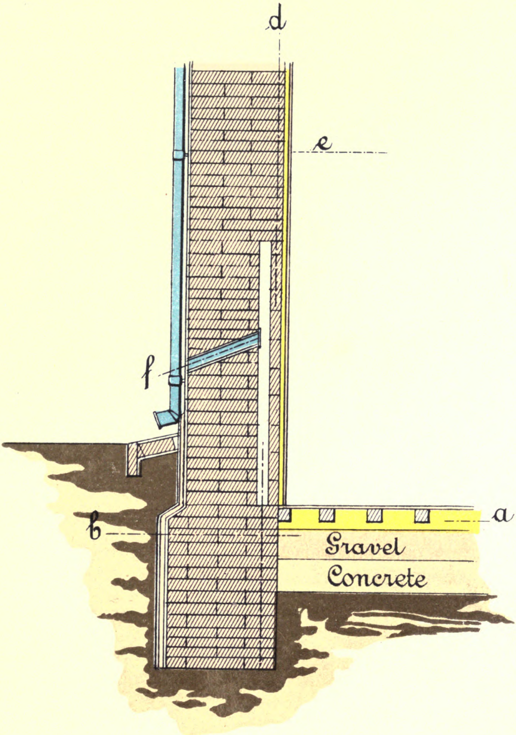

Fig. 16.

c and *d*) flush with the inner surface of the wall, and leaving a cavity behind; the wall is then dried and furnished with a wainscot (Fig. 16, *e*). The hollow space behind the false wall must be put into communication with the outer air by openings (Fig. 16 *f*) 2 or 3 inches in diameter, every 10 or 12 feet in the length of the walls, so that the inner surfaces may have the opportunity of drying without any draught being caused in the room itself.

The Berlin "Bauhygiene" Association, which employs Seemann's process, as described above (p. 44), has obtained very satisfactory results by the following method of preventing the rise of ground moisture :—

"As low down as possible in the wall of the building, or just above the floor boards when there are cellars below them, holes are bored into the wall 10 inches apart. If the wall is a thick one, the holes should extend quite through it. The fire-boxes with air-blast, already described, are then set to work on both sides of the wall, at the level of the bore-holes, until the brickwork is thoroughly heated and dried. In the Charlottenburg Palace this result has been attained with walls 1 metre (39 inches) thick. Whilst the brickwork is still quite hot, and therefore in a highly absorbent condition, pipes are screwed air-tight into the bore-holes, and by means of a force-pump bituminous oils are forced into the dried stratum of the wall."

Even should this operation fail to produce an absolutely continuous damp-proof course in the wall—which depends on the structure of the mortar and the bricks—it is nevertheless in practice found that in all cases the hot wall absorbs sufficient of the material to prevent the rise of ground moisture.

This method has been applied with complete success to the Royal Palace at Charlottenburg, the Imperial Ingenheim Villa at Potsdam, the L'Aronge Villa at Neu-Babelsberg, and other places. Compared with the methods heretofore in use it presents very decided advantages.

2. OPERATIONS OUTSIDE THE BUILDING.

Throughout the entire length of the wall, or some yards beyond it, the soil should be excavated down to the bottom of the wall, the joints well scraped out, a coat of cement mortar laid on, and a layer of roofing tiles applied whilst the cement is soft, and these again covered with ordinary mortar. This treatment should be continued to a height of 10–12 inches, or up to the ground level. Above this, for a distance of 12–16 inches, the old cement is to be removed, the joints scraped out, and pointed with cement mortar. If a supply of clay is accessible, a layer of this 10–12 inches thick is thrown into the trench, the old soil returned, and the whole rammed firm. Finally, a sloping stone pavement, about 16 inches wide, should be laid in cement at the foot of the wall, finished off with a narrower strip of stone placed on edge (Figs. 17 and 18).[1] This paving throws off all the water from the rain-water pipes, and has been found to be a satisfactory expedient in cases in which many other means had been inefficient. A still simpler but equally effectual method is to cover the whole outer side of the foundations with a layer of good concrete a foot in thickness.

By the adoption of the above treatment in its entirety, the dampest, coldest, and consequently most unhealthy apartment may be in a very short time converted into a thoroughly dry, habitable, and healthy one, since the dampness is not merely got rid of for the moment, but actually absorbed and removed, so that the unhealthy organic growths which develop in all damp situations are deprived of the conditions necessary to

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[1] EXPLANATION OF FIGS. 16, 17, AND 18.—Fig. 17 represents the lower part of a wall which has not been treated for the purpose of drying it, and where the flooring of the basement apartment is above the outside ground level. Fig. 18 shows the same wall after treatment in the manner prescribed. Fig. 16 shows a similarly treated wall, where the flooring is at a lower level than the street pavement.

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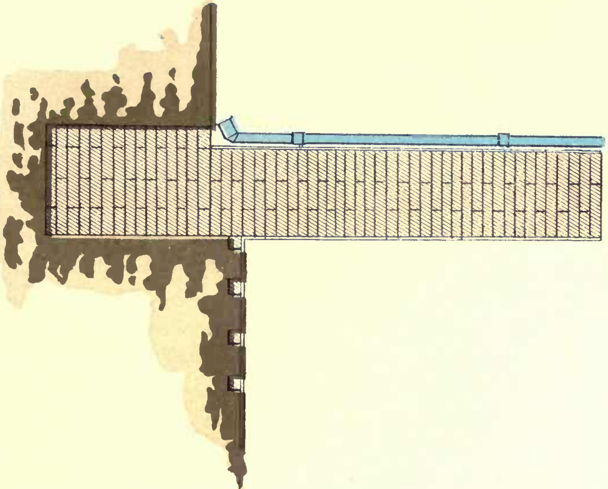

Fig. 17.

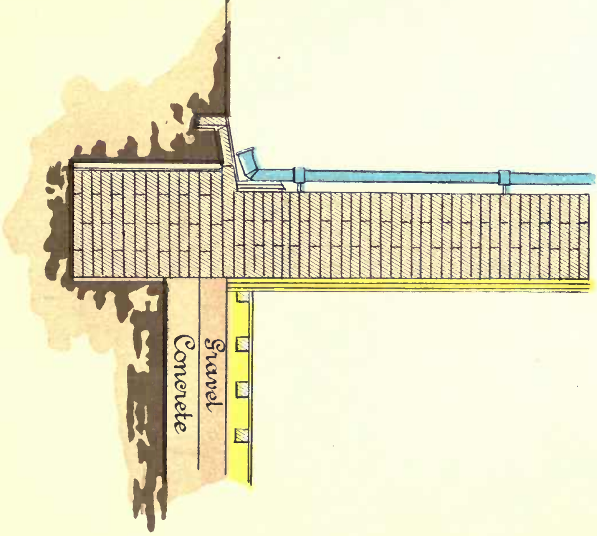

Fig. 18.

their existence, and the air can no longer be contaminated by the products of their decomposition.

As the materials here advocated are all of mineral origin, they are decidedly to be preferred to others of combustible nature. The treatment here prescribed does not in any way interfere with the porosity of the walls, so that the diffusion of air through the walls, which is of such great importance as a means of ventilation, is not impeded.[1] The calcium hydroxide in the mortar, which, in addition to the other causes, contributes to the dampness of the brickwork by requiring a long time to part with its chemically combined water, is completely dried and carbonated, so that even with regard to durability the walls are improved. Dry walls allow more diffusion of air to take place than damp ones, the pores of which are filled with water; they furnish to the dwellers in the house a purer, warmer, more healthy atmosphere, not loaded with water vapour; they are more permanent than damp walls, in which the water itself, when it has absorbed the various vapours exhaled by man and animals, constitutes a destructive agent for both mortar and stone.

In short, a process has here been described which is both efficacious in preventing access of damp from any quarter and is also permanent in its results. Assuming good materials and conscientious workmanship, the process cannot fail to be efficient, since it is no empirical one, but is based on the laws of physics and chemistry. It must in any case be more effective than such remedies as lead paper, asphalt paper, glazed tiles, oil or tar paints, etc., which, as Vaudoyer truly remarks, can have no function than that of a watertight barrier, which in the most favourable cases merely prevents the moisture from coming to the surface, and tends to drive it to other parts of the wall. The water vapour which in an ordinary dwelling-room arises from the exhalations of human beings and from the operations of washing and cooking, and which condenses on the cooler parts of the walls, is by such devices prevented indeed from soaking into the brickwork, but is not actually got rid of. The copious deposits of condensed moisture which form on the cooler parts of the wall have far less opportunity of evaporating there than would be the case if they penetrated into ordinary porous brickwork, where they would be distributed over a much more extensive surface, and would present to the air more numerous points of contact.[1]

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[1] Both in the case of walls dried by this process and in other cases, it is advisable to remove any old wall-paper or whitewash before applying new, and to rub down the surface with a piece of sandstone, so that the pores may not be blocked up with old colour, size, or paste. It is also to be recommended that a room treated as described should every six to ten years have a thorough heating with the object of expelling every trace of moisture from the packing material.

In conclusion, the use of hollow wainscoting, with ventilating channels, must not be overlooked; such wainscot, whether of bricks, wood, or even pasteboard or linen, if the interspace is not ventilated, serves merely to hide the damp wall, provide a home for vermin, and allow the accumulation of damp, impure air, whilst often encouraging a luxuriant growth of vegetation behind.[2]

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[1] Pettenkofer, who demonstrated the porosity of brickwork by blowing out a candle through a wall, says, "Our walls must very frequently absorb condensed moisture, arising in part from the household operations, in part from respiration and perspiration, and afford it passage through their substance, until it reaches the outer surface, where it evaporates in the open air."

[2] Schülke, *Gesunde Wohnungen* (Healthy Dwellings), p. 99, says, "The air of a room is affected not merely by all the impurities derived from outside, etc., but in the most carefully shut-up rooms it becomes vitiated, owing to its stationary condition, and in such stagnant air organic growths, mould, and even vermin, thrive and increase. The musty smell of a long shut-up room is well known, and the examination of the dust, which in such a room settles on all the exposed surfaces, shows that it often is half of organic origin. Still worse are the impurities introduced into the air of a room by human beings and their occupations. The respiratory and perspiratory processes alter not merely the normal composition and dampness of the air, but both the lungs and the skin give off organic exhalations. These are precipitated with the condensed water vapour on walls and furniture, and increase the amount of organic matter in the atmospheric dust. Smith collected such

The process here described has none of these disadvantages, but has the very decided advantages which have been already specified.

For walls only superficially damp, which it is intended to ornament with valuable decorative painting, the following method, for which a patent (No. 22,600) has been granted to me, is suitable. It presupposes that, as completely as possible, the cause of the dampness has been removed.

The wall surface, freed from all the old plaster, and with the joints cleared out to a depth of half an inch, is exposed for a few days to dry air, then brushed down, and plastered with a very thin fluid mortar, made with $1\frac{1}{2}$ measures of cement, 2 measures of clean quartz sand, and $\frac{1}{2}$ a measure of manganese ore, laid on thick enough to permit special clay plates to be pressed into it. Not more of the mortar should be employed than is absolutely necessary for this purpose. The special clay plates, which are 0·8 to 1·0 cm. in thickness, are made from good porous clay, of two sizes. Supposing that one plate measures 40 × 20 cms., the other should measure 5 mms. less, or 39·5 × 19·5. The larger plate *A* (Fig. 21) has one surface grooved as shown at *a*, Fig. 20; the smaller plate has also one surface ribbed. After drying, both plates have their flat surfaces covered with a glazing composition, and they are then placed together in pairs with the flat glazed surfaces applied to one another, and, as shown in Fig. 21, the smaller plate extending on two of its sides beyond the edges of the larger one, so that at the opposite edges about 2 cms. of the glazed surface of the larger plate are exposed. The plates are then fired, and become joined together by the glaze. When this compound

organic exhalations in the water-drops condensed on the walls of his leaden chamber. The deposits gave on burning the characteristic smell of singed feathers, decomposed rapidly, and after a few days formed a slimy mass with a copious development of mould and other fungi. It is the opinion of physicians that these exhalations are poisonous, and the researches of Hammond and Solokoff support this opinion."

plate is applied to the plastered wall, the mortar enters the grooves *a a*, and holds the plate so firmly that after drying it can only be detached in fragments.

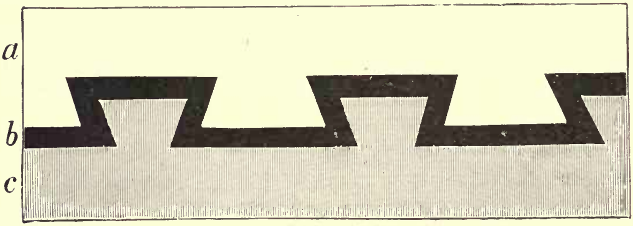

FIG. 19.

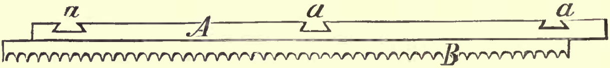

FIG. 20.

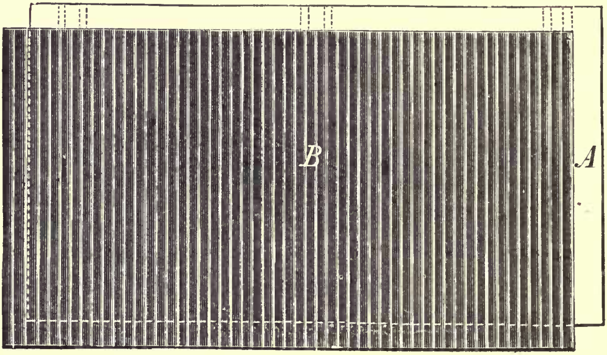

FIG. 21.

The ribbed side affords a very large surface for the adhesion of the stucco. The mode in which the plates are attached prevents the penetration of moisture through the joints of the back plate, because these are all covered by the projecting edges of the front one. The front plates, being 5 mms. smaller each way than the back ones, do not meet one another, but leave spaces which have the glazed surface of the back plate at their bases. These joints are then filled up with tow which has been worked up with a mixture of tar, asphalt, turpentine, and powdered oxide of manganese to a thick dough, which is then melted by a hot soldering bit, so that it only half fills the joint. This melting should, however, be deferred until the wall has dried for a day or two. The whole surface is then floated with a thin stucco composed of

3	Measures	of washed quartz sand,
2	,,	coarsely crushed marble,
2	,,	slaked lime (paste),
1	,,	Portland cement,
1	,,	infusorial earth, and
1	,,	powdered marble.

Max Röhm, architect, of Munich, employs the so-called hollow Italian terra-cotta plates for covering the fronts of houses and walls which are to be decorated with paintings. These plates, which are distinguished by their lightness, porosity, and resistiveness, are manufactured in sizes from 20 to 100 cms. long, 20 to 25 cms. wide, and 3 to 6 cms. thick.

Good dry wainscot partitions can be constructed by the process of Joseph Monier of Paris (German patent, No. 14,673), according to which an iron framework is covered with cement. Ventilating channels, by which the space behind the wainscot is put in communication with the outside air, are equally necessary here.

Excellent isolating partitions, with means of ventilation, may be obtained by using the so-called "Rabitz-Putz." Rabitz holds a patent (No. 4590) for the construction of self-supporting partitions, as well as one for the use of wire-netting as a support for cement (No. 25,255).

The following description of the invention is taken from the specification of the latter patent. The preparation of light fireproof partitions, for which patent No. 4590 was granted, is hereby extended to the construction of double walls; the air space between the thin cement partitions preventing the passage of heat or sound. The same system may be made use of for forming isolated coverings for walls, with a ventilated air space between the partition and the brickwork.

The essential feature of the invention is that all contact of the wire-netting, or other support of the cement, as well as of the cement itself, with the beams and girders, is avoided. The mortar employed for these partitions consists of (marble) lime, gypsum, sand, calves' hair, and size, to which also fire-brick dust, and pumice, fireclay, slag powder, crushed shells, powdered marble, asbestos, iron oxide, infusorial earth, red lead, alum, common salt, and water-glass may be added.

I would here remark that I entirely discard the use of gypsum, size, alum, common salt, and water-glass for all rooms which it is proposed to dry, and that, provided the plaster is not laid on too thin, and is not dried too quickly, there is nothing better than good ordinary mortar, with the addition of calves' hair, or else a cement mortar consisting of 1 part of cement and 4 parts of clean sand, to which a little lime is added to increase its adhesiveness.[1]

In the case of walls which are only slightly damp, and to which any further access of moisture has been prevented, the following treatment may be adopted for the inner surface. The old plaster is removed, the joints are scraped out to the depth of an inch, the wall is well brushed down and dried by one of the heating appliances. It is then replastered with a mortar made up of 1 part of Portland cement and 2 parts of fine washed sand, which is laid on at most $\frac{1}{2}$ cm. thick. This is allowed to dry slowly so as to attain its requisite hardness. The wall is then warmed again, and whilst hot there are given to it two coats of Keim's "Isolirmastix," which, whilst still hot, is well strewed with sand, in order that the plaster (Trockenputz) may adhere to it firmly. Instead of plaster, I have likewise employed porous clay plates 2 cms. thick, coating these on one side with hot isolirmastix, and then applying them with pressure to the still hot wall. Twelve hours later a coat of good lime or cement mortar (not gypsum) may be given to the clay plates, and when this has hardened the room may be heated up.

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[1] On the subject of lime and cement mortars, the reader may be referred to the frequently cited work of Gottgetreu, and to that of Dykerhoff & Sons on *Portland Cement*, where will be found valuable information on the preparation of concrete, cement mortar, stucco, etc.

The special plaster (Trockenputz) mentioned above is made of—

100	parts	(by weight)	of Portland cement.
10	,,	,,	of quicklime.
110	,,	,,	of washed and dried sand.
4	,,	,,	of chopped wood-wool.
9	,,	,,	of fine sawdust.
28	,,	,,	of powdered wood charcoal.
33	,,	,,	of calcined infusorial earth.

These substances are well mixed in the dry state, and the mixture passed several times through a coarse sieve. It is then worked up with water to the consistence of a very stiff mortar, using not merely the ordinary mortar rake, but thoroughly and for a long time kneading the paste with the béton rammer until it is brought to a thoroughly uniform, smooth condition. This is then applied to the wall to a thickness of 2 to 4 cms., laying on, however, only 1 cm. at a time, and allowing several hours for setting. The room is then kept shut up for about a week that the plaster may dry very slowly. During this period it should be wetted daily with a fine spray of water; for this cement, if allowed to dry with insufficient water, does not become hard. The first wetting should take place twenty-four hours after the plastering has been finished, and the room shut up. After the lapse of a week the wall may be dried by fire. This plaster is only suitable for the inner surfaces of the walls of dwelling-rooms.

For cases in which the walls are only superficially moistened by condensation of water vapour from within, which is always the case when a dwelling-room, a church, etc., has thin walls which rapidly cool, it suffices to increase the thickness of the wall by applying a layer of this plaster. The use of the undercoat of cement and the isolirmastix can be dispensed with.

The aforesaid "isolirmastix" consists of the following mixture:—

21½	parts of	Cooper's pitch.
6	,,	Syrian asphalt.
10	,,	linseed-oil varnish.
2	,,	coal tar.
3	,,	paraffin.
4	,,	white lead.
15	,,	burnt umber
2	,,	slaked lime.

The pitch, asphalt, and paraffin are first melted together in an iron kettle, the linseed-oil varnish is then stirred in, and when these are well mixed the dry powders are added. Lastly, 4 parts of oil of turpentine are stirred in. This varnish must always be applied to the warmed surface until it will no longer soak in, but forms a glistening film on the surface. This preparation can be preserved for any length of time in closed vessels, and for use must always be remelted when required.

A material which may be strongly recommended for coating damp walls is the flexible pasteboard "Kosmos," patented by Fischer and manufactured by the firm of A. W. Andernach of Beuel-on-Rhine. The adjoining Fig. 19 shows a section of a wall, in which *a* is the old brickwork, *b* the flexible pasteboard, and *c* the plaster laid over it. For the plaster the firm recommends that cement mortar should be used, which, on account of the uniform drying (because independent of the drying of the brickwork), speedily acquires a stony hardness, and is held very firmly by the dove-tailed grooves of the pasteboard and the sand which is strewed on its surface. The pasteboard itself is watertight and damp-proof, and keeps the inside plaster permanently dry, except in cases where the moisture comes from the air of the room itself and is condensed on the surface of a wall which is too thin. In such a case it would be advisable to cover the wall to the thickness of an inch with my special plaster (Trockenputz). If (as I strongly advise) holes are bored through the outer brickwork, so as to admit the external air to the hollow spaces between the bricks and the flexible pasteboard, the old wall will gradually become dry, without the inhabitants of the room being incommoded by any draughts. The pasteboard is also absolutely proof against rotting. This simple, cheap, and in most cases adequate treatment, deserves the greatest consideration, and its value will be confirmed by a practical trial. It is especially to be recommended in cases where the inner surface of an old and damp wall is to be decorated with painting. In all cases it is important that all the old plaster should be removed from the wall to which the pasteboard is to be attached, and that no new plaster should be laid on, so that with lapse of time the wall may become completely dry. The operations on the outside of the wall, described on page 62, must not be neglected. Readers will find full information in the valuable pamphlet "Falzbaupappe 'Kosmos' nach Patent Fischer, verfasst von A. W. Andernach in Beuel-am-Rhein. Commissionsverlag von Breitkopf & Härtel, in Leipzig, 1899."

I conclude this part of the subject by giving a short summary of the individual causes of dampness in houses, with the remedial operations adapted to each special case.

1. The dampness is due to insufficient drying of a newly built house.

Remedy: removal of all wall-paper, scraping off colour wash and oil paint from the brickwork, drying by heat, introduction of good ventilation arrangements, and thorough aëration.

2. Cause: permanent ground moisture.

Remedy: introduction of impervious substances into the wall above the foundations to produce a damp-proof course; drying the walls by heat; formation of an independent or inner casing, containing air or infusorial earth, on the inner surface of the wall. Lastly, the use of Fischer's flexible pasteboard. The outer surface to be freshly stuccoed with good Portland cement to a height of a yard above the damp places.

In cases where the ground moisture is due to temporary causes only—

Remedy: it is unnecessary in this case to introduce waterproof materials; all that is required is to dry the walls by heat, and coat the wall with Fischer's flexible pasteboard.

3. Rain-water which has drained down the walls and accumulated in the neighbourhood of the foundations.

Remedy: cementing the outer surface of the foundations or cellar walls with Portland cement mortar made with 1 part of Portland cement and 2 parts of sand. The water must be drained away, the wall replastered, air shafts constructed. Inside: drying by heat, and furnishing with a wainscot. In slight cases, Isolirmastix and Trockenputz.

4. Cause: driving rain or water splashed from the ground.

Remedy: plastering the outer wall with Portland cement mortar to a height of a yard above the soil, or over the whole surface affected. Drying by heat. On the inner surface, a wainscot. In slight cases, some waterproof layer attached to the surface, and fresh plaster. Lastly, the application of Keim's Trockenputz.

5. Causes: condensation of water on the inner surface resulting from the exhalations of the inhabitants, or water vapour arising from domestic operations coming in contact with walls which are thin and consequently cold.

Remedy: if the wall is saturated it must be dried by artificial heat, and an inner casing, with air space behind, constructed. If the wall is only superficially damp it should be coated with some waterproof material, and then with a layer of Trockenputz.

6. Causes: efflorescences, hygroscopic building materials, etc.

Remedy: see No. 5.

7. For damp walls which it is required to decorate with painting.

Remedies: *A*—Outside, a dry area. *B*—Inside, an independent tile or brick wall, or else the use of Keim's double tiles, or Fischer's flexible pasteboard.

8. Cause: damp from inundations.

Remedy: drying artificially. If the brickwork is quite saturated, a layer of infusorial earth or an air space behind tiles. In other cases, a covering of a waterproof substance and Trockenputz. Constant ventilation.

In principle, and in their true or assumed mode of action, there exist the following differences between the older and the newer methods of drying damp walls and dwellings:—

1. Simple drying by artificial heat is sufficient in all cases where further access of moisture has been excluded, and where the building materials are of good quality and not hygroscopic. Cases are rare in which damp can be got rid of by mere ventilation, although this is a valuable means of protection against the occurrence of damp walls in buildings, and one which is not generally sufficiently appreciated. Every dwelling-house ought to be provided with arrangements for thorough and regular ventilation.

2. Simple waterproof isolating layers between the brickwork and the plaster, such as sheets of glass, glazed clay tiles, lead or tin foil, coatings of tar, asphalt, and similar compositions, such as Weissang's cement, Keim's isolirmastix, if employed in a skilful and suitable manner, and with a superposed plaster of

good, non-hygroscopic materials, will dry both the inner and outer surfaces of a wall. They both prevent the entrance of moisture into the wall and hinder that which is present in the brickwork from making its appearance on the surface. They further preserve even hygroscopic bricks and mortar from becoming damp, provided the access of moisture from below is cut off. But where access of moisture or its distribution in the wall cannot wholly be prevented, these waterproof materials must be applied to the inner surface only, since by shutting up the moisture in the brickwork by waterproof coatings applied to both sides the moisture would simply be compelled to ascend to a higher level.

The saturation of the brickwork with fatty or bituminous solutions has a similar effect, but closes the pores to the diffusion of air. Applied to the foundation walls, such solutions act as a hindrance to the rise of ground moisture.

3. The so-called Trockenputz, or porous, unglazed clay plates, act as non-conductors of heat, and, in consequence of their porosity, promote the uniform distribution of any moisture which may condense on them, and, unless their capacity for absorption is exceeded, which under normal conditions in human dwellings cannot occur, promote its rapid evaporation.

They serve for facing solid stone walls, or for adding to the thickness of thin walls, which they protect from a too rapid cooling. They are only suitable for interior surfaces. They have the great advantage of not interfering with the ventilation which takes place through the pores of the brickwork.

The same purpose is served by the hollow Italian terracotta plates of Max Röhm, which are equally suitable for facing the outer surfaces of damp walls, whilst the highly porous cements must be used only for interior work. For exterior surfaces it is necessary to employ either good ordinary mortar or Portland cement, these being the only materials which sufficiently resist the action of the weather.

4. Wainscot walls, with ventilating channels communicating with the outer air, or with the space between wall and wainscot filled with infusorial earth, are undoubtedly the most radical remedy. They keep the inner surface dry, and, if coated with a sufficiently thick plaster, are very warm. They make it possible for the brickwork to dry spontaneously if further access of moisture has been prevented or is inconsiderable, although under all circumstances it is better to dry the brickwork artificially, and to adopt all the precautions against further entrance of damp into the wall which have been described in this book.

5. The plan of exposing hygroscopic preparations, such as quicklime, calcium chloride, etc., to the air of a room with damp walls, with the intention of absorbing the moisture, is altogether inefficient. The most they can do is to dry the air in cases where the room has been rendered damp by a temporary cause, and this result can be attained quite as well by warming and aërating the room.

The selection of the means to be employed depends, then, upon the extent of the mischief, on the materials which are available, the outlay contemplated, and the taste and intelligence of the workman. An accurate study of the causes and remedies, and especially of the principles according to which the latter act, will best enable anyone to select the simplest, most efficient, and most suitable process.

PART II.

CHAPTER I.

ON THE CAUSE AND ORIGIN OF "DRY-ROT," ITS INJURIOUS EFFECT ON HEALTH, ITS DESTRUCTIVE ACTION ON BUILDINGS, AND ITS SUCCESSFUL REPRESSION.

AMONGST the varieties of fungus which attack wood, the most destructive, objectionable, and dangerous, both for buildings and for their inhabitants, is the *Merulius destruens*, *vastator*, or *lacrymans*, which produces the effect commonly known as "dry-rot" (Hausschwamm, Gebäudeschwamm). It belongs to the class of Cryptogams (Thallophita), some of which are only visible with the microscope, although others are of large dimensions. It was at one time supposed to originate by spontaneous generation, and to be produced by the fermentation and decomposition of wood, but it is now well established that it is only propagated by spores. Moisture, warmth, darkness, deoxygenated air, and the presence of decomposing organic matter, are, nevertheless, factors which favour its development and growth.

According to Prof. Goeppert, the native habitat of *Merulius lacrymans* is the pine forest (it does not occur in the wood of leaf-bearing trees), where in damp, dull spots it is found on rotten tree-stumps, etc., and where, in outward appearance, it resembles some other species of fungi. This botanist gives the following description of dry-rot: In outward appearance this fungus is very variable, its form depending more on external conditions than on its individual characteristics. Its propagation does not depend, as many persons even now believe, on accidental circumstances, such as dampness, rottenness, etc., but is carried on, like that of other plants, by seeds, which in the case of cryptogamic plants are called spores. It commences its growth as a network of soft cylindrical cells called *mycelium*, which penetrate the substance of tree roots, stems, and leaves. Its growth is rapid, not according to any definite type such as is exhibited by other plants, but rather such as is conditioned by its environment; it spreads in soft, web-like fibres over the surfaces of wood and brickwork, often in masses several feet long, with a tendency to a fan-shaped extension, penetrates into the cells, vessels, and medullary rays of the wood, disintegrates it into long, four-sided rods, and in a proportionally short time reduces it to a friable condition.

Where local circumstances do not afford it room for development, it forms thin bands or cords of 1 to ½ inch wide, which penetrate all the joints of the brickwork and even the bricks themselves, and in a short time extend from the deepest cellars through the whole of the upper structure. In suitable situations it comes to the surface and reaches the stage of developing its fructification, which, being the means of its propagation, is its most mischievous state. External conditions exercise great influence on the form of the fructification. The following description is sufficient for our present purpose. In dark localities where the spores are present, there are first developed roundish, warty, succulent patches, of the size of peas, which develop into reticulated bands, thicken in the middle, and very soon throw off spores or seeds. The reticulated bands gradually increase in size, grow together and form rounded masses, which produce an immense number of brownish spores. The mycelium gives rise to a thick spore-bearing layer, which at first has the appearance of being covered with a delicate down, and then acquires a yellowish red colour. This cake develops on its surface a honey-combed layer, scientifically designated the hymenium, which also produces spores. On being touched its colour alters; it becomes almost instantly wine-red, then dirty brown, and finally black. The extremely minute, brownish red spores, which are only $\frac{1}{300}$th of a line in diameter, are when ripe projected with almost incredible force to a distance of several feet, so that a considerable surface is often found to be covered by them. At the time when the spores become ripe, the surface of the mass secretes a fluid, which is first clear but later becomes turbid and milky, and possesses a disgusting flavour. To this liquid, which has not yet been examined chemically, the fungus owes its specific name of *lacrymans* (weeping). This liquid assists the extension of the fungus, by keeping the wood in a constantly damp condition, and by promoting its decomposition and the preparation of suitable nutriment. When the fine filaments of the mycelium penetrate a mass of timber and decompose it, the phenomenon constitutes the ordinary "dry-rot." It is often associated with wood-boring insects; the decomposed wood falls to powder and exhibits the fibrous network of the fungus both in its interior and on its surface.

This fungus continues to grow as long as it finds healthy wood to supply it with nutriment, and only perishes when the supply of decomposable wood is exhausted. In the process of decomposition carbonic acid gas is evolved, and water is withdrawn which was previously in combination with the unoxidised carbon of the wood fibres. The action of the fungus is, however, not confined to the increase of the carbonic acid and the diminution of the oxygen, but it establishes a fermentation or rotting in the organic substances upon which its influence is exerted, resulting in the formation of hydro-carbons, ammonia, carbonic acid, and water as final products.[1]

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[1] For further information see Hartig's *Die Zerstörungen des Bauholzes* (The Destruction of Building Timber), Berlin, 1885; Dietrich's *Die Hausschwammfrage* (The Dry-Rot Question), Berlin, 1895; Gottgetreu's *Die Hausschwammfrage*, Berlin, 1891; Gotschlich's *Die Hygienische Bedeutung des Hausschwammes* (The Influence of Dry-Rot on Health), Leipsic, 1895; Dr. Ferd. Cohn's "Ueber den Hausschwamm" (On Dry-Rot) in the *Breslau Gewerbeblatt*, 1885.

Shortly summarised, the conditions favourable to the production of dry-rot are: The employment of materials from an old building, of building ground which is damp and contains decayed vegetable matter, of timber which is wet or already affected with the fungus; painting the woodwork too soon, and using building materials of hygroscopic nature, containing spores or soiled by human or animal excrement; imperfect drying of a new building; insufficient ventilation, or improper use of the dwelling-rooms, stables, etc., permitting the development of aqueous vapour without removing it, will all contribute to the same result.

The secretions and effluvium from this fungus, which disseminate a mouldy, cadaveric odour, as well as the spores which it communicates to the air, are in the highest degree injurious to health, and may be the cause of nervous disorders such as headache and giddiness, affections of the mucous membrane of the throat, diphtheria, fever, etc. The mischievous effects of the presence of dry-rot in a dwelling-house, both on the health of the inhabitants and on the structure itself, should on no account be underrated. And knowing the terrible ravages which it is capable of producing in a very short space of time, and which may even result in the complete ruin of a building, it is easy to understand the efforts which for a long time have been made to endeavour to counteract it.

CHAPTER II.

METHODS OF PREVENTING DRY-ROT, TO BE ADOPTED DURING CONSTRUCTION.

BESIDES the avoidance of the causes briefly summarised in the last chapter, a careful attention to the rules laid down in Chapter II., Part I., is of the first importance. Wood felled at the wrong time of year, or insufficiently seasoned, ought to be avoided; care should be taken that the ends of the timbers do not come into immediate contact with still damp brickwork, or with any decomposing organic matter; the thorough drying of the new work should be provided for, and also for regular ventilation of all parts of the building. If, for the sake of still greater precaution, it is desired to make use of preservatives, they may be selected from those mentioned in the present chapter. But it should be remembered that such errors as the employment of unsuitable materials, or the incorrect employment of even good materials, etc., or neglect in avoiding the causes mentioned above, may render any preservative application utterly ineffective. As such, however, there may be recommended the so-called antimerulion, a solution of water-glass (sodium silicate), applied after the wood has been saturated with common salt, respecting which we shall give more details later. According to the latest experience, the treatment of the wood with creosote is most strongly to be recommended.

The Hasselmann method of treating wood introduced by the

"Süddeutsche Imprägnirungs-Geselschaft G. m. b. H. of Haar, near Munich," is a most efficacious preventive of dry-rot. Prof. J. E. Weiss[1] of the Royal Technical University of Munich and the Imperial Physiologico-Chemical Laboratory of Klosterneuburg, gives a most favourable report on this process, and confirms the statements of the inventor that the strength of the wood is unaffected by the impregnation; it can therefore be used equally with unimpregnated wood for all constructive purposes. And considering that wood impregnated by Hasselmann's process is much less inflammable, and is not liable to attack by micro-organisms, it is most desirable that such wood should be made use of where the object is the production of first-class building construction. In consequence of the horny consistence imparted to the wood by this preservative process, all warping after the wood has been worked is prevented, and window-frames, doors, and door-posts made from such wood undergo neither shrinkage nor distortion. Attack of the wood by vermin is also prevented by the chemicals which the treated wood contains.

The process, which is patented in Germany, consists in boiling the wood under pressure, by which means the albuminous and proteid constituents are coagulated. Antiseptic agents are also employed, amongst which ferruginous copper sulphate is the most effective. Aluminium sulphate, together with potassium sulphate in the form of kainite, is also employed.

That the chemicals completely permeate the wood, and are uniformly distributed over the cell walls, may be demonstrated by various chemical tests, as, for instance, by potassium sulphocyanide, which produces a characteristic red colour with iron. In cases where the iron is so firmly combined with the wood fibres that it does not give the reaction immediately, it may be dissolved out from its combination by means of hydrochloric acid, and the colour will then be produced instantly. Potassium ferrocyanide produces the characteristic blue coloration, but requires that the iron should be extracted by hydrochloric acid from its organic combination. This is a proof that the sulphate of iron has undergone decomposition, and no longer exists in the wood in its original condition; otherwise, the formation of Prussian blue would take place without the use of hydrochloric acid. The substances with which the wood is impregnated can therefore no longer be dissolved out by water, and this secures the preservation of the wood for a very long period.

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[1] See *Bayerisches Industrie-und Gewerbeblatt* of 7th March 1898.

For the preservation of railway sleepers, Charitschoff[1] makes use of naphtha and naphtha products. Buchner,[2] according to the German patent No. 11,123, starting from quite a different point of view, employs chrome-alum. He first softens the cell walls, and by boiling under pressure removes the resin, which would prevent the penetration of the solution, and the sap constituents and extractive matters which form the first nutrient material for fungi and bacteria and initiate the decomposition of the wood itself. Having done this, he hardens the sterilised wood again by boiling for several hours with an appropriate solution of chromic oxide.

According to Wittstein, Buchner, and Dr. Egger, the "Impregnation Process for Woodwork" of Conrad Gautsch of Munich has proved very efficient. It protects the wood from fungi and rotting, and renders it incombustible without any injury to its appearance. I have been unable to learn any details of this process.

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[1] *Bayerisches Industrie-und Gewerbeblatt*, No. 34, of 25th August 1900, p. 270.

[2] *Bayerisches Industrie-und Gewerbeblatt*, No. 34, of 1st September 1900, p. 278, "Ueber Holzconservirung" (On the Preservation of Wood).

CHAPTER III.

OLD METHODS OF PREVENTING DRY-ROT.

G. L. W. VON BÜHLER, in his work *Die Schwamm in den Gebäuden, etc.* (Fungoid Growths in Buildings, etc.), gives it as his opinion that, with the object of rendering wood less liable to the attack of fungi, it should not be used until it has been deprived of the special organic constituents which exist in an unlignified and unevaporated condition in the wood. The pure wood, by which term he designates the solid residue of the vegetative processes, has in general the composition—

Carbon	52·53	per cent.
Hydrogen	5·69	,,
Oxygen	41·78	,,

and is to be regarded as the most durable part of the wood. As soon as a tree is cut down, the sap, which contains water, potassium acetate, calcium carbonate, sugar, albumin, tannin, with other extractive matters, begins to undergo chemical changes, instead of being the seat of the vital processes of vegetable nutrition. Evaporation and drying proceed with a rapidity which is dependent on the original fluidity of the sap, on the higher or lower external temperature, on the intensity of the light to which it is exposed, and the degree to which the vessels of the plant are expanded and opened. Any of the sap which does not in this manner become removed from the residue (the pure wood) passes in a longer or shorter time into a condition of putrefaction, which it then communicates to the lignified residue. The first problem would therefore appear to be, to discover methods by which the pure wood may, as soon as possible after the death of the plant, be freed from those easily decomposable organic constituents, in order that their decomposition in contact with the pure wood may be hindered or rendered wholly impossible. It will readily be conceived that this separation of the unlignified sap from the pure wood can only be effected in the simplest manner, if the wood has been felled at a time when the sap is in a fluid condition and capable of evaporation, that is to say, from the middle of February till early spring,[1] and that not merely for the best building timber, but for wood intended for any other technical purpose, this is an indispensable condition. Thoroughly dry, well-seasoned timber is undoubtedly the best for all purposes, and builders naturally select the best seasoned which is obtainable, without considering the scientific reasons for so doing. Where, however, the greatest degree of strength and permanence is required, as in shipbuilding and machine construction, artificial means are employed for freeing the wood as completely as possible from the unlignified sap. Long keeping under water, lixiviation, boiling, steaming, and treatment with metallic salts are methods for effecting this.

The views of Von Bühler on the origin of fungoid growths amount to this, that he does not consider that spontaneous generation can be demonstrated, although we daily see organic life arise without any evidence of special generation: thus, lichens appear on decomposing rock, algæ in water, and fungi in organic substances undergoing decomposition. On the contrary, he admits that fungi are developed from spores. For counteracting the growth of fungi and the rotting of wood, and for making the wood more durable, only such means are of use as will prevent the action of moisture, remove the fermentable substances from the interior of the wood, and replace them by more stable compounds, without detriment to the other properties and constituents of the wood.

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[1] Gottgetreu, *The Physical and Chemical Nature of Building Materials*, vol. i. p. 369, has the following remarks on the time for cutting timber for building: "The time at which felling takes place has great influence on the strength and durability of wood. Formerly it was considered best to cut it in December, because at that period the sap in the wood was thickened, and the pores of the wood appeared more nearly closed; but more recently it has been asserted that no great difference exists between the durability of wood felled in winter and summer if the trees are properly treated immediately after felling. If the wood is allowed to lie with the bark on for several months, it of course loses its vitality more readily in summer than in winter, etc."

And p. 270: "Comparative experiments with wood cut in December and in March under similar circumstances have proved that the December wood was 38 per cent. stronger than that cut in March, and had twice its durability."

The problem may be solved in other ways than that proposed by him, which, however, he regards as the only correct way, and the one most certain to effect the object desired.

According to Bleichrodt, the most efficacious method of preventing dry-rot consists in establishing abundant ventilation. A strong air-draught should be allowed to pass through the rooms infected with the fungus, and the air-current is, if possible, allowed to pass under the flooring of such rooms as are usually affected by damp. The soil should be wholly removed, the earth impregnated with saltpetre; disease germs and fungus spores, as well as all rotten, crumbling wood, carefully taken away; the space filled up again with dry sand, powdered charcoal, etc., and the flooring replaced. If a hollow space is left under the floor boards, the evil will be radically cured; the germs of the fungi and the saltpetre efflorescence will be got rid of as long as pure atmospheric air is allowed free access to this hollow space. Time and labour should not be expended in an attempt to destroy the fungus by washes of acids, vitriol, etc., so as to save the apparently sound but affected wood. A new foundation, new sills, and door-posts will prove durable in a permanently dry and airy environment.

Not only should free access of pure air be allowed to the aforesaid hollow space under the flooring, but simultaneously ventilation should be established, which will prevent the air in the rooms from becoming stagnant. We know by experience that a current of air is immediately produced if a window and a door in the opposite wall are opened. The cause lies in the difference between the temperatures of the outer air and that in the room ; the colder air entering and displacing the warmer until an equilibrium is established. For this reason the draught ceases as soon as an equilibrium of temperature is attained, and for the same reason in rooms heated by a stove an air-draught towards the stove always occurs. If, therefore, a similar air-current can be produced under the floor boards of a room, it is evident that all damp, stagnant air will be swept away by it. But a mere opening through the wall of a room to put the outer air in communication with the space below the flooring will not suffice to produce an air-current. It is necessary to provide means of drawing in the outer air, and for this purpose the stove with which the room is warmed may be utilised. Such a stove is the best purifier of the air of a room, for as it uses up the air contained in the room, this is immediately replaced by external air, which enters at every opening ; and this exchange of air continues as long as the stove is warmer than the surrounding atmosphere. If, therefore, the stove is put in communication by suitable openings with the space below the flooring, the damp, impure air will be drawn into the fire, and its place will be taken by the pure air from outside.

Let us, says Bleichrodt, suppose a room on the ground floor of a house, which has been subject to all the evil effects of a damp situation, and which is to have its condition improved by means of a hollow-laid flooring. After the preliminary steps for attaining the desired object have been taken, the wet earth from below the flooring has been deeply dug out, and all rotten, crumbling wood has been removed, the space is filled up with clean, dry sand, charcoal powder, iron slag, or similar substances which do not absorb moisture, to the height of the outer ground level, or, where the circumstances permit, even higher, and the surface is levelled. Rows of brick piers 3 feet apart are now built, the piers having a height of 4 to 6 inches and a base of a square foot.[1] These are intended to support the joists of the boarded floor, assuming that such a floor is contemplated. Through the external wall which bounds the room openings of 30 to 40 square inches are cut, so as to admit the external air to the space below the floor. These openings are protected with gratings. The joists are now laid down on the piers, and upon them the floor boards. The planks for the flooring may either be grooved together, or, better, a false floor of rough, unplaned, but grooved deals is laid, and upon these a second or parquet floor.

Bleichrodt admits that such a floor cools the place seriously, and recommends further the introduction of a complete layer of beams, with the interspaces filled up with brushwood or straw.

The hollow space below the floor boards being thus provided, and the external atmospheric air being allowed to reach every point, the next thing is to arrange for an air-current through the space. This is effected by means of the stove,[2] which stands in one corner of the room. The outward shape of the stove is quite immaterial; its interior must, however, be arranged as follows: "A tube, of wrought iron, cast iron, or stoneware, of 50 to 60 square inches sectional area, but widened out below to the form of a funnel, is carried vertically through the fire-box of the stove, opens below into the space beneath the floor boards, and above either into the open air or into a loft. This tube carries away some of the heat of the stove, and this is a necessary condition, but it is not a chimney for the products of combustion, and care must be taken that it does not communicate with the stove flue." According to Bleichrodt, this method will dry the space below the flooring completely, and will put an end to the conditions under which fungoid growths are capable of existing.[1]

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[1] In English house-building it is more usual to employ sleeper walls (honey-combed for circulation of air) for supporting the joists, although separate piers are sometimes used.—Note by Translator.

[2] In Germany, the open English fireplace is almost unknown. The rooms are warmed by a fire burning in a closed stove which stands on the floor of the room entirely detached from the walls. The arrangement described in the text is adapted to the German stove only.—Note by Translator.

A similar method is advocated by the firm of Girbig, Posen, & Schulz of Berlin.

Schacht has proposed to destroy the fungus germs in wood by heating the wood in steam to 100° C. (212° Fahr.) before using it. See Nöthling.

Other means of destroying fungoid growths may be divided into two groups: the harmful and the harmless. The harmful means may again be subdivided into (*a*) those injurious to human health, (*b*) those which damage the wood and brickwork to which they are applied, (*c*) those which introduce risk of fire. Besides these there are a certain number of older remedies, the efficiency of which, however, has been to some extent disputed. It is, however, indisputable that many of these, for instance common salt, have only failed to give successful results where the mode of employing them has not been sufficiently thorough.

1. HARMFUL MEANS OF DESTROYING FUNGOID GROWTHS.

(*a*) *Poisons.*

Corrosive sublimate (mercuric chloride, hydrargyrum muriaticum corrosivum).—Kyan in the year 1834 suggested as a means of preserving the timber employed in shipbuilding that it should be treated with a solution containing 1 part of corrosive sublimate in 50 parts of water. The efficiency of this preparation results from its combining with the vegetable albuminoids of the wood and undergoing reduction to mercurous chloride (calomel). In this way a new organic compound is produced which is insoluble and not acted on by moisture, and which, consequently, cannot enter into fermentation, which is the first stage of rotting. In addition to this it behaves as a metallic salt, closing up the pores of the wood and preventing the access of air and moisture. This preparation has in all cases proved effective both against rotting and the growth of fungi. It is, however, somewhat expensive, and, on account of its poisonous character and its tendency to volatilise, is inadmissible for inhabited rooms. Moreover, since the wood requires to be saturated with it, its use is both troublesome and tedious.

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[1] On arrangements for producing a circulation of air, see Emerich, "Ueber Luftcirculationsanlagen," Romberg's *Zeitschrift*, 1861.

H. Meiner, *Das städtische Wohnhaus der Zukunft, etc.* W. Thiele: Stuttgart, 1879.

H. Schülke, *Gesunde Wohnungen.* J. Springer: Berlin, 1880.

J. Schmölke, *Die Verbesserung unserer Wohnungen, etc.* J. Bergmann: Wiesbaden, 1881.

M. H. Tölken in 1842 recommended arsenic dissolved in water for destroying fungi. The places affected by fungoid growths and all neighbouring localities were to be painted with this solution. It is needless to say anything about the dangerous character of this proposal.

(*b*) *Materials Destructive of Wood and Brickwork.*

In this class are to be placed all the free mineral acids, muriatic (hydrochloric) acid, oil of vitriol (sulphuric acid), aqua fortis (nitric acid), since these attack and destroy both wood and brickwork.

Equally injurious, under some circumstances, are various salts which have been used for this purpose, such as calcium chloride, zinc chloride, iron chloride, etc., which decompose the brickwork with which they come in contact, and therefore, whilst curing one evil, produce another. Such substances should not in any case be brought in contact with bricks and mortar.

(c) *Inflammable Remedies.*

Ethereal oils, oil of cassia, creosote, and, according to Taylor, gasoline, etc., may indeed have a temporary effect, but involve a serious risk of fire, on account of their inflammability.

M. Hochberger (*Deutsche Industriezeitung*) has indeed recommended petroleum as a remedy, and with regard to this the editor of Wagner's *Jahresbericht*[1] remarks that in consequence of its inflammability its use is to be deprecated, quite apart from the risk of the user being looked upon as a "Petroleur."

2. HARMLESS REMEDIES.

Alkali waste.—This substance, mentioned in Gottgetreu's treatise on building materials, is a mixture of carbonate, sulphite, hyposulphite, and sulphide of calcium. It should be spread upon the earth thrown into the foundation trench, especially where this comes in contact with wood, and be well rammed in. It has the property of combining with water and hardening to a firm cement; it therefore withdraws moisture from woodwork, and has proved very successful.

H. Müller, Building Surveyor in Bremen, has employed the following process, which by his account has always been effectual:—

"To extirpate dry-rot completely, it is necessary not only to clear away the affected wood, and any of the earth below the floor which shows the presence of fungus, but to destroy any germs which may be contained in the walls, before coating them with cement. To this end, after the floor boards and the loose earth below them have been removed, the whole of the plaster should be removed from the wall to a height of about four feet, the joints of the brickwork scraped out, and then the wall be thoroughly wetted with ordinary pyroligneous (acetic) acid. This must be repeated several times a day, and the walls be exposed as freely as possible to fresh air and light. When the walls are again thoroughly dry—which, however, may take some weeks—they are replastered with good cement mortar, and the joists are relaid on a bed of dry sand, free from vegetable mould, and then the flooring planks nailed down. The skirting boards are so arranged that between them and the brickwork a space is left in which a circulation of air can take place. The treatment of the fungus with acetic acid causes it to shrink up, and on the places to which the acid has been repeatedly applied it will no longer grow."

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[1] Wagner, *Jahresbericht*, xix. 870.

We have, however, numerous reports on this process which deny the permanence of its effects, and personally I believe it not to be an effectual remedy.

Another well-authenticated remedy consists of a mixture of 1 lb. of copper vitriol, 1 lb. of muriatic acid, and 1 lb. of sulphuric acid. It is necessary to be careful how this mixture is applied on account of its strongly acid character.

A further means of destroying fungus and preventing its recurrence is that of Kastner, consisting of turf ash with common salt and sal-ammoniac. Four bushels of turf ash, 6 metzen of salt, and 1 lb. of sal-ammoniac are stirred up with boiling water to a thin pulp, and with this the foundations and the earth below the floor are liberally treated. This remedy is said to have been very successful, and has shown no objectionable after-effects.

Tölke recommends the use of vitriol, alum, and common salt solutions for the destruction of fungus.

In Wagner's *Handbook of Chemical Technology*, as well as by Ehrlich, the use of water-glass is advocated as a means of protecting wood against fire, and attention is directed to its antiseptic properties. A soda water-glass solution of 33° is diluted for use with an equal weight of rain-water. When applied to wood it fills up the pores of the wood with a deposit of insoluble silicic acid, and protects its surface from the action of air and moisture, and therefore from rotting. Any fungus spores which come in contact with wood thus treated are unable to develop. In the event of a fire such wood does not burst into flame, and, according to a communication made by District Surveyor Heim to the *Gewerbeblatt*, 1878, No. 51, in several cases of fires in buildings which had had their woodwork treated with water-glass, the spread of the fire had been hindered. A notice of its antiseptic properties appeared in the *Chemische Centralblatt* in 1872 and 1873, and it has elsewhere been repeatedly recommended as a remedy for the attacks of both fungi and insects. Its cheapness, and the facility with which it can be applied, strongly recommend it, but the results will only be satisfactory if the wood has first been well dried. Before applying water-glass to wood, an application of common salt (sodium chloride) is strongly to be recommended, as this possesses pronounced antiseptic properties. Gottgetreu indeed recommends the saturation of the wood with salt alone. He also makes use of a liquid containing 250 grams of salt and 187 grams of sulphuric acid to a litre of water, such a solution having been more effective than one of salt alone. A treatment with water-glass might follow either of these.

As a protection for woodwork it has been recommended to furnish the ends of beams with caps of sheet-lead or other metals. Another proposal is to bore a hole in the end of the beam and fill it with a mixture of salt and train oil. The salt is a powerful protective against rotting, and by mixing it with a liquid fatty substance such as train oil, its penetration into the pores of the wood is assisted (H. Müller).

The following preparation for protecting the ends of beams is used in Sweden: To a solution of 4 lb. of zinc vitriol in 90 lb. of hot water there is added 10 lb. of rye flour stirred up with 30 lb. of cold water, and then a solution made by heating 3 lb. of rosin with 20 lb. of train oil. The whole is thoroughly mixed, and the mixture may be coloured by adding any mineral colour. It is laid on the wood whilst warm.

Others have recommended that powdered iron vitriol, copper vitriol, or culinary salt, should be scattered on the earth beneath the flooring, also treatment with solutions of zinc sulphate or chloride.

The process invented by Payne consists in soaking the wood first in solution of sulphate of iron and then in lime water, by which means the iron solution in the pores of the wood is precipitated. This process has only been employed for small pieces.

Boucherie's process consists in impregnating the wood with a solution of copper vitriol, which is forced into the end of the grain from an overhead reservoir.

Raulin has indeed asserted, on the ground of experiments conducted by himself, that iron and zinc compounds do not prevent fungoid growths, but actually favour them. This statement requires confirmation.

Weyrach, in his *Betractung des Hausschwammes* (Considerations on Dry-Rot), published in 1797, remarks that "The growths of fungus which constitute dry-rot very soon burst when they reach open air, and then distil a yellow sap and pass into the special form of *Schwamm*, but soon after die. He argues from this that the only possible means of getting rid of the fungus is to scrape away the exterior growths, when the roots will die in consequence of the repeated removal of the visible portion of the plant. Held, however, is convinced of the inadequacy of this method, since the vigour of the roots of the fungus is in no way impaired by the constant removal of the exterior growth.

According to Baumgarten, gaseous sulphurous acid has so destructive an effect on the fungus and its spores as to kill them completely. Brockmann has found bisulphite of lime equally effective.

According to Reisenbichler (*Deutsche Tischler-Zeitung*, No. 5, 216), dry-rot may be safely and thoroughly got rid of by exposing the affected wood to superheated steam. This is obtained by boiling a concentrated solution of calcium chloride in a small steam boiler, from which the steam escapes through a long, narrow slit. The dry steam, impinging with some force on the wood, is supposed to wither all the spores which cause the mischief, and get rid of it completely. To guard against a fresh development of the fungus, the still warm wood is to be saturated with a salt of copper or mercury (!) and the metallic salt is to be enclosed in the fibres in an insoluble form, by giving a subsequent coat of a solution of soap.

Oscar Hornig supplies a carbolate of soda, under the name "Klippel's House Preservatory," as a remedy for dry-rot. This is prepared from 10 lb. of crude carbolic acid, ½ lb. caustic soda, and 1 lb. of water. Its effect should be highly satisfactory, but it has the characteristic odour of carbolic acid.

Dr. Winkelmann of Augsburg employs the following process for rendering wood fireproof and for destroying and preventing dry-rot. A solution is prepared, containing 33 grams of manganous chloride, 20 grams of orthophosphoric acid, 12 grams of magnesium chloride, 10 grams of boric acid, and 25 grams of sal-ammoniac in a litre of water.

Another process for effecting the same purpose consists in boiling the wood in a solution of potassium sulphate, and, after drying, heating it with a mixture of coal tar and clay. The wood is then coated with a paint containing asbestos and fireclay, which is fixed by a steaming process. For further details see Heinzerling, *Die Conservirung des Holzes* : Halle, 1885 ; and Andés, *Die Conservirung des Holzes* : Vienna, 1895.

CHAPTER IV.

RECENT AND MORE EFFICIENT REMEDIES FOR DRY-ROT.

PROF. SOROKIN'S estimable treatise on dry-rot (*Baugewerkszeitung*, 1884, p. 467) gives the following conclusions with regard to the destruction of this dangerous fungus, which are based on exhaustive experiments and researches :—

1. An air-draught destroys the fungus in twenty-four hours.

2. Light has a powerful influence in hindering the development of the fungus. The simultaneous action of light and an air-current will destroy it in a few hours.

3. Wetting the wood with a solution of common salt prevents the attack of the fungus.

4. A concentrated solution of copper sulphate is even more effectual.

5. Carbolic acid destroys the fungus in a short time.

6. Common birch oil is a thoroughly efficient household remedy for dry-rot; the painting of the joists and the lower surface of the floor boards with it is a certain preventive. The cheapness of this substance, and the simplicity of its employment, render birch oil the most generally applicable remedy for this evil.

Amongst the newer remedies for dry-rot there are two which have for a long while competed with one another for precedence, and both of which have given most satisfactory results. These are the so-called "Mycothanaton" and "Antimerulion." Finally, there is to be considered the so-called

"Carbolineum Avenarius," which indeed presents the greatest advantages.

Besides the above, boric acid, aluminium acetate, and salicylic acid have been used as antiseptics and remedies for dry-rot. Bruns recommends aluminium acetate on account of its property of preserving animal substances from rotting; even in small proportions this salt prevents the decomposition of animal matter, and completely destroys bacteria. According to my own experience, a solution of it should be brushed over the woodwork.

Prof. Franz Farsky, of the Agricultural Station at Tabor, has destroyed dry-rot by salicylic acid, which he employs in the following manner: "At first salicylic acid was used in the solid form, the affected spots being sprinkled or rubbed with the finely powdered acid. After the lapse of a few days it was observed that the patches which had been sprinkled were partly, those into which the acid had been rubbed were wholly, destroyed. This satisfactory result was, however, not permanent; the fungus soon reappeared, but only on spots with which the salicylic acid had not come in contact. A second experiment was now made with a solution of salicylic acid, the affected spots being treated with a saturated solution. The result was more favourable; it is, however, still more advantageous to employ an alcoholic solution, since a litre of alcohol dissolves about 5 grams of salicylic acid. By the employment of less than 5 grams of salicylic acid in alcoholic solution" (the author omits to state how much alcohol was taken; the reporter in Biedermann's *Centralblatt für Agriculturchemie* conjectures that more than 1 litre of alcohol must have been used) "two floors of 72 square metres surface, two door frames, and the adjacent brickwork were treated as a protection against the spread of dry-rot. At the present time, after a lapse of eight months, there is no dry-rot in either of the rooms, although one of them contains the copper of an experimental brewery, and the other the apparatus for experimental spirit distillation, and in spite of the fact that in a neighbouring locality a large amount of organic matter was allowed to rot a year ago, and to become a nucleus for a free distribution of fungus spores.

"It may be remarked that crude salicylic acid can be used, this being both cheaper and, owing to its containing less carbolic acid, more efficient than the pure acid."

A. Thieke makes use of hydrated oxide of iron as a protective against fungus and insects. He fits sheet-iron caps to the ends of the beams, and pours sulphuric acid into a hole in one of the caps (German patent).

Fischer's patents, as worked by the firm of Andernach at Beuel-on-Rhine, provide for covering the building timbers with tar pasteboard, which protects them from damp, and for a free play of air round the beams in position, thus preserving them from fungus and rot.

According to Wittstein, J. Müller supplies, under the name "Mycothanaton," a solution of 750 parts of calcium chloride, 1500 parts of Glauber's salt, 60 parts of corrosive sublimate, 500 parts of water, and 2500 parts of muriatic acid.

Under the same name a liquid has been introduced into commerce by Vilain & Co. According to the instructions for use supplied by Vilain & Co., this liquid is to be heated to boiling in an iron kettle, and thickly laid on with a brush whilst hot. Any woodwork on which the fungus shows itself is to be laid bare, and after thorough cleansing and removal of the fungoid growths, is to be treated with the hot liquid. The soil below the floor is also to be saturated with the hot liquid, whereby any spores that may be present are immediately killed. The solution, when applied to wood, is absorbed, and coats the cell walls with a thin crust which completely protects them from air and moisture.

Brickwork, before treatment with mycothanaton, must have all plaster cleared away and the joints scraped out to a depth of ½ inch, so that the liquid may soak into the brickwork properly. Any joints not readily reached by a brush may have the liquid squirted into them with a syringe. If a single affected spot exists in a room, it is advisable to treat the whole room with the liquid, because the fungus spores, which are invisible to the naked eye, may have settled at other spots, where they will develop unless prevented by a treatment with mycothanaton. Before laying down the flooring of a room infected by dry-rot, it is necessary that the walls from a foot below to a foot above the boarding should be stripped of their plaster and be saturated with the hot liquid. There is no doubt that by this means dry-rot can be completely got rid of.

Various chemists have analysed this preparation, but with results which differ much from one another.

According to Hager, the liquid consists of common salt, alum, sulphuric acid, and water, with traces of arsenic and iron. Ballo, in a specimen which he examined, found 1·16 gram of oxides of iron and aluminium, 1·47 gram of copper oxide, 16·72 grams of magnesia, 99·99 grams of sulphuric acid, and a considerable amount of hydrochloric acid in a litre. He regards the solution as the waste liquor from the preparation of carbonic acid gas from magnesite and sulphuric acid, to which muriatic acid has been added. The liquid has an acid reaction, attacks brickwork strongly, and keeps the spots to which it is applied damp for a long time.

Prof. Jegel of Hof takes it to be a solution of sodium chloride mixed with sulphuric acid, which probably is a waste liquor from the manufacture of potash salts at Stassfurt. In any case, the price at which it is sold is far too high, being at least two-thirds above its real value.

Experiments made with it by the author, with their results, will be reported below.

An excellent remedy for dry-rot, which has attracted considerable notice from builders, is that known by the name "Antimerulion." Dr. H. Zerenner of Magdeburg took out a patent in 1877 for a process for protecting buildings against dry-rot (German patent, No. 378, Class 37), which is thus described in the specification[1]: Starting from the point of view that the introduction of ventilating channels during construction has for its object the replacement of foul air by fresh, in order to protect the woodwork from the attacks of fungi and to preserve the flooring in a dry condition, one is led to inquire whether the same result might not be obtained by a simpler method than the above, which, although it fulfils the purpose, is rarely applied in practice to private houses. These considerations indicate a substance which is supplied to technology by ancient alluvial deposits, namely, kieselguhr, or infusorial earth. The hygroscopic character of this material was pointed out in 1838 by Prof. Hausmann, who was the first to describe the substance in the *Göttinger Gelehrtenanzeigen*, Nos. 14 and 15. Since that time kieselguhr has remained almost unnoticed, although a few years ago it was adopted for the manufacture of dynamite, and has in a few cases been recommended as an isolating material, whilst its remarkable capacity for absorbing moisture and for withdrawing it from the air and neighbourhood has remained unapplied.[2] This property renders it all the more noteworthy as a substitute for a current of dry air, because other hygroscopic substances present the disadvantage of liquefying when they absorb water. Kieselguhr is indeed especially suitable as a drying agent, since it is capable of absorbing five times its weight of water. The supply of the material is amply sufficient to admit of its use on the large scale. When used alone, especially under circumstances where the amount of moisture present is in excess of its absorbing capacity, it does not confer absolute security against the development of dry-rot. It is, therefore, proposed to add to the kieselguhr a substance which is highly inimical to the growth of fungi, namely, sodium chloride, and, for prevention of putrefaction, a powerful, inodorous antiseptic, boric acid; of the former 6 per cent. and of the latter 3 per cent.

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[1] Full information respecting this process is to be found in the pamphlet, *Beitrag zur Kenntniss, zur Verhütung, und zur Vertreibung des Hausschwammes*, by Dr. H. Zerenner. Baensch, jun., Magdeburg.

[2] Dr. Reinhold Hofmann, in 1875, drew attention to the absorptive capacity of infusorial earth for liquids, as well as to its value as a bad conductor of heat. See *Neueste Erfindungen und Erfahrungen*, 1874, 460; 1876, 125, 436. A. Hartleben, Vienna.

The use of sodium chloride alone would produce damp spots on the walls which would not dry up; the hygroscopicity of the kieselguhr counteracts this tendency. The action of the prepared kieselguhr is as follows: As long as it is able to absorb moisture, it keeps the floor boards, joists, etc., dry, and thus removes the conditions necessary for the growth of fungus; but if, in consequence of abnormal weather, or other local or accidental circumstances, the moisture should be so much increased that the kieselguhr is incapable of absorbing it, the sodium chloride and boric acid begin to exercise their antiseptic properties and neutralise the injurious effects of the dampness, until the latter is got rid of and the kieselguhr resumes its absorbing functions.

Under normal conditions the absorbing power of the kieselguhr can scarcely become exhausted, since 1 c.c. of it is capable of taking up an immensely greater quantity of water than is present in 1 c.c. of air saturated with moisture.

The antiseptic properties of boric acid are so well known that it is unnecessary for me to say anything on that subject.[1]

The prepared kieselguhr is an important substance both in hygienic and financial aspects, since it prevents the destruction of the woodwork in a building and the occurrence of the dangerous diseases of timber, such as fungus growth, dry-rot, etc. The mode of using it is described in the pamphlet already mentioned; it consists in employing it for filling up the space beneath the floor boards. Although the air below the planks is thus kept in a pure, dry condition, I do not consider that all the possible precautions for the preservation of the wood are thereby exhausted. The wood may have been already affected by the disease before it was felled, or fungus spores may have been introduced into it whilst the building was in progress. Under these circumstances it does not suffice to prevent the development of the mischief by external means only; it is necessary to combat the spread of the mischief by internal treatment.

---

[1] *Archiv. Pharm.*, 1874, ii. 520; *Dingl. Journ.*, 1871, ccv.; Dr. F. Soschelt, *Wiener landw. Zeitung, etc.*

To this end I have sought for a liquid with which the wood might be painted, and by means of which the same antiseptic substances might be introduced into the pores of the wood. Such a liquid is water-glass, which, if of suitable concentration for the purpose (25° Bé.), is easily laid on, and speedily fills up the pores of the wood with a precipitate of insoluble silicic acid.

The water-glass is mixed with sodium chloride and boric acid (or an equivalent amount of the sodium salt) in the same proportions as those employed for the kieselguhr, with the precautions necessary for preventing gelatinisation.

The sodium chloride and sodium borate (borax) penetrate easily and deeply into the wood, whilst the sodium or potassium silicate fills up the pores of the wood with the silicic acid precipitated by the carbonic acid of the air, and prevents the admission of moisture or the spores of fungi from without, whilst locking up the active constituents inside.

The simultaneous employment of this preparation of water-glass and of the prepared kieselguhr furnishes an equally cheap and certain means of protecting woodwork from putrefaction and fungoid growths, keeps the flooring dry and warm, and, therefore, is more to the purpose than the hitherto employed constructional precautions.

The process for preserving the woodwork of a building, securing a dry basement floor, and destroying the dry-rot fungus, consists in the use of the two preparations described above, which, to emphasise their simultaneous use, and considering that they both contain the same percentage of antiseptic agents, both bear the same name, "Antimerulion."

With the liquid antimerulion all the woodwork to be protected—planks, beams, uprights, etc.—as well as the infected brickwork is to be once or twice painted over, the ground under the flooring so thoroughly soaked that the liquid obviously reaches and destroys all the mycelium present, leaving none to penetrate into neighbouring rooms.

With the dry antimerulion the beam ends should be surrounded to a thickness of about an inch, and the whole of the planking isolated from the walls. The space behind the panels should also be filled with it.

The protection which it affords against a recurrence of the dry-rot fungus is complete, as is shown by the following experiment: Three planks of the same wood were taken; one of them received two coats of the antimerulion, the second only one coat, and the third was left untreated. They were then buried in the ground and surrounded with wood strongly infected by dry-rot. After the lapse of four months they were dug up, when the fungus was found to have developed luxuriantly. The untreated plank was completely destroyed by the fungus, whilst both the treated boards were quite free from it. Numerous reports from other sources all speak favourably of the results obtained with this remedy.

To sum up the results of our inquiries into the methods of preventing the appearance of dry-rot, it will suffice if the precautions against dampness which are described in Chapter II. of Part I. are carefully observed during the building of a house. The space below the floor should be filled up with dry gravel, slag, or infusorial earth; the timber employed should be sound and dry, and, for better security, should be saturated with a solution of common salt and then with a dilute solution of sodium silicate (water-glass) before using it. The cost of this treatment is inconsiderable; all the woodwork of a house of medium size could be treated with water-glass at a cost of twenty to twenty-five shillings.

In cases where it is necessary to eradicate a growth of the dry-rot fungus which is already developed, it is obvious that poisonous remedies, those injurious to wood or brickwork, and highly inflammable ones, must be avoided. Of other remedies we have no general approval, the opinions of both experts and the general public being somewhat adverse, and after the exclusion of the above inadmissible classes there remain for consideration only salicylic acid, sodium chloride dissolved in water-glass solution, mycothanaton, and antimerulion. With regard to salicylic acid the experience is still too scanty and recent to permit it to be definitely recommended; it is highly desirable that further experiments should be made with this substance in order to obtain greater certainty respecting its behaviour. In a case which came before me, in which a fungoid growth required to be extirpated, I treated one-half of the woodwork with mycothanaton, the other half with antimerulion. Both preparations killed the fungus completely, and up to the present time (about three years) not the smallest trace has shown itself again. Some of the planks treated with these preservatives were in 1879 removed and sawn through. That treated with antimerulion was perfectly sound and not attacked in the least; the same was the case with the brickwork to which this preparation had been applied. The mycothanaton, on the contrary, seemed to have attacked the wood; at the places where it had been applied the surface of the wood no longer retained its natural hardness. The foundation walls also which had been treated with the solution had the appearance of having been affected by saline efflorescences. For these reasons, and also in consideration of the high price of the article, I recommend the use of antimerulion in preference to mycothanaton.

My mode of employing it has been as follows (I should, however, explain that for some years I have only had three cases of dry-rot to deal with): The whole of the affected wood and plaster and the earth beneath the floor were carefully removed, the walls were well dried by artificial heat, and a fresh floor, of new wood, well dressed with the preservative, was laid down. The walls were replastered, and the whole place was again thoroughly dried before it was inhabited. The results were perfectly satisfactory, but I would call attention to the necessity of doing the work thoroughly, and extending the precautions to a distance of some yards from the places actually affected.

A new remedy for dry-rot is that called antinonnin, invented in 1894 by Prof. Dr. W. von Miller and Dr. K. Harz, and consisting of potassium dinitrocresol, water, and soap.

At the present time the so-called carbolineum avenarius[1] is being widely advocated as a means of destroying and preventing the growth of the dry-rot fungus, and is giving excellent results. This substance is a by-product obtained in manufacturing anthracene from coal tar. It has also been described as a tar product to which alcohol and other antiseptic substances have been added. According to the German patent, No. 46,021, heavy coal tar oils are slightly warmed and run into a cylindrical vessel furnished with a stirrer, and here vigorously churned whilst treating them with chlorine gas. The changes resulting from the treatment with chlorine are shown by the following comparisons :—

---

[1] *Naturwissenschaftl. technische Rundschau in Jena*, 1888, iv. part 11.

	Crude Carbolineum.	Chlorinated Carbolineum.
1. Viscosity (30 c.c. occupied in flowing from the same orifice)	3′ 6″	4′ 50″
2. Flash point of the vapour about . .	130° C.	133° C.
3. Burning point about	150° C.	160° C.
4. Specific gravity at 15° C. . . .	1.1217	1·1303
5. Distillation (100 parts yielded distillate below 350° C.)	1·8 parts	1·5 parts

The peculiar and offensive odour of the crude carbolineum is, moreover, replaced by an agreeable one. The tendency to dry is increased in the same proportion as the viscosity, and the liquid when laid on a surface dries with a varnish-like gloss. The fluorescence disappears, and the chlorinated carbolineum exhibits a chestnut-brown colour, and communicates this colour to the wood to which it is applied. Lastly, the chlorination produces a marked increase in the antiseptic properties of the substance. When laid hot on wood it evaporates the moisture present, penetrates the pores of the wood, and surrounds the wood with a protective coat which preserves it from the action of moisture. It is not dangerously inflammable, and, in spite of its extensive employment, no case of fire has occurred in which it has played a part. On the other hand, creosote and similar substances give off a vapour which is easily inflammable, and are at the same time less efficient.

A single coat, which should be laid on hot, is sufficient for a preventive. Even where the fungus has already obtained a hold, it may be destroyed by liberally applying the preservative to the affected wood, as well as to all the parts of the walls on which the mycelial fibres are present. Before doing this, the places affected should be laid bare, all corroded wood should be planed down to the sound wood, all the rotten material cleared off, and, after appropriate exposure to the air, the wood is to be twice coated with the hot oil.

Figs. 22 and 23 show the difference between two wooden posts exposed to the same conditions, of which one was treated with carbolineum avenarius and the other was not.

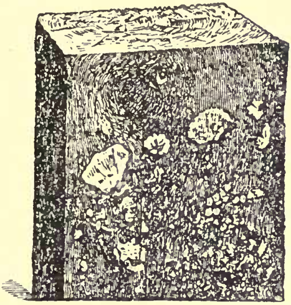

FIG. 22.

Section of a quay-post from the wharf of Messrs. Prince constructed in 1888 on the Gold Coast. This post was treated with carbolineum avenarius, and after five years' exposure exhibited no injury from the attacks of animals or from rotting.

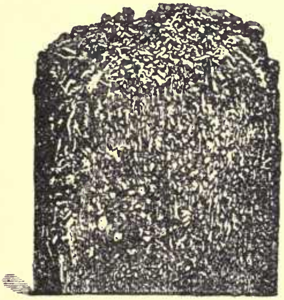

FIG. 23.

Section of a quay-post forming part of the wharf of Messrs. Watson on the Gold Coast constructed in 1893. This post was not treated with the carbolineum ; the figure shows its condition after two years.

It appears to me to be a point of great importance that this preservative can be applied to brickwork without any injury to the bricks or the mortar, whilst *all* other remedies containing salts, alkalies, or acids attack the bricks and mortar more or less, and thus produce one evil in extirpating another. Another advantage, pointed out by the manufacturers, is that any kind of plastering adheres well to the wall surfaces to which carbolineum has been applied. No special apparatus is required for using it; the warmed liquid is simply laid on with a brush.

From the fact that all the reports on the practical use of this preservative during many years agree as to the success of the results obtained with it, we may conclude that this preparation is the most effective known for the prevention and extermination of the dry-rot fungus. This, and its moderate price, would appear to finally solve the problem in a satisfactory manner.

In Seemann's patent (No. 76,877), already mentioned (p. 44), the following method for the destruction of the dry-rot fungus in houses is given: "The interstices between the planks of the floor are closed up by applying varnish, or some similar means. Holes are then bored through the boards, or through the ceiling of the room below, and through these holes chlorine gas, or any other gas which will kill the fungus, is passed. The holes are then closed by plugs. The gas penetrates into all the crevices in the space between floor and ceiling, and effectually destroys the fungus."

This method may indeed dispose of any fungus actually present, but does not, like the carbolineum avenarius, protect the wood from attack at a later time.

In the present treatise I have supplied both professionals and the general public with the means of forming individually an opinion on the causes, nature, and rational methods of counteracting dry-rot, as well as the reasons for rejecting the use of such remedies as corrosive sublimate, acids, various salts, petroleum, gasoline, mycothanaton, etc., and have therefore fulfilled the purpose for which this work was undertaken.

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